FINAL

FEASIBILITY STUDY

MEDLEY FARM SITE
GAFFNEY, SOUTH CAROLINA

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SIRRINE PROJECT NUMBER G-8026.20

SIRRINE ENVIRONMENTAL CONSULTANTS
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3.0 BASELINE RISK ASSESSMENTS

3.1 INTRODUCTION

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This chapter presents the baseline evaluation of the human health risks and environmental endangerment posed by site-related chemicals on and potentially migrating from the Medley Farm Site. The objective of the risk assessments is to describe any potential risk to the public health and/or the environment as a consequence of the uncontrolled release of residual chemicals from the Medley Farm Site. The risk assessments provide input to the development of remedial alternatives for the Site by identifying what risks need to be reduced or eliminated and what exposures need to be prevented.

3.1.1 Risk Synopsis

For the future residential land use scenario, the risk assessment indicates an estimated carcinogenic risk due to exposure to site-related chemicals of 1.1×10^{-2} for all pathways combined. This risk is driven by the ground water ingestion pathway. It is above the EPA remediation goals of 10^{-4} to 10^{-6}. Total estimated non-carcinogenic hazard for future residential use of the Site is 5.6, due entirely to ground water ingestion. Possible concern for potential noncarcinogenic health effects is indicated.

There is no significant carcinogenic or non-carcinogenic human health risks nor is environmental endangerment to wildlife expected under current land use conditions. The cumulative carcinogenic human health risk at the Site is presently estimated as 8.6×10^{-7}. This current risk is less than the acceptable risk level of 1×10^{-6} and the EPA remediation level goals of 10^{-4} to 10^{-6} for site remediation. The current risk level is attributable to site soils as there are no ground-water receptors on the Site or near the down-gradient property boundary at present. The potential for non-carcinogenic human health effects (hazard index $= 2.9 \times 10^{-4}$) is below the EPA hazard quotient of one that would indicate a potential for adverse effects. No potential for significant risk to wildlife on the property is expected to occur.

3.1.2 Site Background

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The Medley Farm Site consists of approximately seven acres of agricultural land in rural Cherokee County, South Carolina. Disposal of industrial waste materials occurred at the Site from 1973 to 1976. A detailed description of the Site and environs, and a history of waste disposal and removal activities at the Site are presented in Chapter 2, Summary of Remedial Investigation. Chapter 2 also presents a summary of RI sampling locations and media, and a description of the nature and extent of chemical residuals identified.

3.1.3 Scope and Organization of Risk Assessment

Investigations conducted at the Medley Farm Site as part of the RI focused on soil, ground water, surface water, and stream sediments as potential exposure media. The risk assessments are based on data developed from these investigations.

The baseline public health and environmental risk assessments have common elements in the evaluation of data from the RI, in respect to identifying chemicals that are likely to be site-related and reporting concentrations that are of acceptable quality. Identification of chemicals of potential concern detected at the Medley Farm Site, therefore, are addressed for both human health and environmental concerns in Section 3.2. Potential public health exposures and associated risks are treated in Section 3.3, and Section 3.4 addresses these elements for environmental concerns. Section 3.5 summarizes the baseline risk assessments.

3.2 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

3.2.1 Data Collection

Data necessary for the baseline risk assessments were collected in three phases during the Remedial Investigation. The field investigations were designed to identify hazardous waste constituents at the Site and their concentrations in key sources and media of interest, characteristics of those sources (especially related to release potential), and characteristics of the environmental setting that may affect the fate, transport, and persistence of site-related chemicals. RI sampling activities were guided by a conceptual model of the Site, which included preliminary identification of potential human and environmental exposure pathways. Media of concern identified were soil, ground water, surface water, and stream sediment. Areas of concern were the Site itself and ground water aquifers below and adjacent to the Site, as well as the nearby perennial stream, Jones Creek (based on potential transport via surface or ground water).

RI activities included a soil gas survey, sampling of soils, ground water, surface water and stream sediments, and a geologic/hydrogeologic assessment of the Site and surrounding area. Chapter 2 presents background and site-related sampling locations and media. Sampling methods and quality assurance/quality control measures are described in the RI Report (February, 1991).

3.2.2 Data Evaluation

The goal of data evaluation is to identify a set of chemicals that are site-related and to select those chemical data that are valid for use in quantitative risk assessment. Sample analyses for the RI were performed by Radian Corporation and Ecotek, both laboratories in EPA's Contract Laboratory Program, in accordance with standard CLP protocols. The analytical results are presented in Appendix L of the RI Report and summarized here in Appendix A.

The limitations and uncertainties associated with the analytical results were evaluated as part of the RI. Analytical results were reviewed in accordance with appropriate EPA data validation guidance (U.S. EPA, 1988a; 1988b; 1989). Background samples were examined in order to identify naturally occurring levels of chemicals and ambient concentrations resulting from non-site sources (anthropogenic levels). The summary list of site-related chemicals and the concentrations detected is presented in Tables 5.3 and 5.7 of the RI Report.

In order to develop a data set for use in the quantitative risk assessments, the following criteria were used as per EPA requirements (U.S. EPA, 1989). If a chemical was detected at or above the Contract-required Quantitation Limit (CRQL) at least once in a given medium, it was identified as a chemical of potential concern. (Contract-required quantitation limit is the chemical-specific level that a Contract Laboratory Program laboratory must be able to routinely and reliably detect and quantitate in a specified sample matrix.) If a chemical was not detected in any samples in a medium, that chemical was eliminated from the data set for that medium. When only some samples in a medium tested positive for a chemical, one-half of the sample quantitation limit is used as a proxy concentration for the non-detected results when representative concentrations are developed in the Exposure Assessment (Section 3.3.1). The results of data collection and evaluation are discussed below for each sampling medium.

Surface Soil

Surface soil samples were collected from 16 locations at the Medley property. Thirteen of these locations were within the former disposal area, and three were outside the former disposal area. Chemical analyses included VOCs, SVOCs, pesticides/PCBs, and inorganics.

A summary of surface soil sampling results can be found in Se   n 2.2.3 and sampling locations are shown in Figure 2.3. Details of sample collection and analyses are presented in Section 3.4 and 5.5 of the RI.

The chemicals detected in surface soil are listed in Table 3.1, along with their frequency of detection and range of detected concentrations. The primary chemicals detected were VOCs. SVOCs were found to a lesser extent. PCB-1254 was detected in only three samples and toxaphene in two. Concentrations of inorganics detected in surface soil samples are within typical background levels.

Seventeen of the 23 chemicals in Table 3.1 were identified as being of potential concern. They are marked with an asterisk. The six remaining chemicals listed were eliminated from the quantitative risk assessment based upon evaluation of the data. Three of the VOCs and one of the SVOCs were eliminated from the quantitative risk assessment because they were detected only once and at a concentration below the CRQL. They are: chlorobenzene, chloroform and toluene (VOCs), and diethylphthalate (SVOC). Two other SVOCs, 1,2-dichlorobenzene and 2-methylnaphthalene, were each detected only twice at levels below the CRQL and therefore eliminated from further consideration.

Ground Water - Saprolite

Ground-water samples were collected and analyzed from ten wells screened in the saprolite, or upper, aquifer. Chemical analyses included VOCs, SVOCs, pesticides, PCBs, and inorganic compounds. Sections 2.1.5 and 2.2.4 contain a summary of ground-water sampling activities and results, including locations of wells (Figure 2.6). A complete discussion of ground-water sampling and analyses can be found in Sections 3.7, 3.9 and 5.7 of the RI Report.

TABLE 3.1

CHEMICALS DETECTED IN SURFACE SOIL
MEDLEY FARM SITE

Chemical	Frequency of Detection	Contract Required Quantitation Limit (ug/kg)	Range of Detected Concentrations (ug/kg)[c]
Volatile Organic Compounds[a]			
*1,1,2-Trichloroethane	2/13	5	110-160
*1,1,2,2-Tetrachloroethane	2/13	5	85-91
*1,2-Dichloroethene (total)	6/13	5	4-200
*1,2-Dichloropropane	1/13	5	21
Chlorobenzene	1/13	5	3
Chloroform	1/13	5	3
*Ethylbenzene	2/13	5	7-33
*Methylene Chloride	11/13	5	2-23
*Styrene	2/13	5	3-11
*Tetrachloroethene	4/13	5	5-69
Toluene	1/13	5	1
*Trichloroethene	4/13	5	7-70
*Vinyl Chloride	4/13	10	25-210
Semi-Volatile Organic Compounds[b]			
1,2-Dichlorobenzene	2/15	330	190-200
*1,2,4-Trichlorobenzene	4/15	330	810-1200
2-Methylnaphthalene	2/15	330	140-160
*Butylbenzylphthalate	5/15	330	140-1100

TABLE 3.1 (Cont'd)

CHEMICALS DETECTED IN SURFACE SOIL
MEDLEY FARM SITE

*Di-n-butylphthalate	4/15	330	78-1100
*Di-n-octylphthalate	4/15	330	3600-5400
Diethylphthalate	1/15	330	110
*bis(2-Ethylhexyl)phthalate	6/15	330	82-33,000
Pesticides/PCB			
*Toxaphene	2/13	160	330-520[d]
*PCB-1254	3/13	160	200-1900

* Chemical of potential concern

[a]Volatile organic compounds and pesticides/PCB are based on data from the following samples: HA-1 thru HA-12, and HA-6-A.

[b]Semi-volatile organic compounds are based on data from the following samples: HA-1 thru HA-12, HA-6-A, HA-16, and HA-16-A.

[c]The range of detected concentrations include estimated results (chemical concentrations less than the contract-required quantitation limit).

[d]Duplicate samples taken at same location.

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The chemicals detected, all VOCs except one, are presented in Table 3.2. No pesticides or PCBs were detected. The concentrations of inorganic compounds detected, when compared with background concentrations measured in the upgradient well, were found to be either at or below background levels or characteristic of natural levels found in local saprolite.

Of the 16 chemicals detected, nine have been identified as chemicals of concern (Table 3.2). The remaining eight chemicals detected were eliminated from the quantitative risk assessment because they were detected only at concentrations below the CRQL: acetone, benzene, bromomethane, carbon disulfide, chlorobenzene, chloroform, toluene, and the one SVOC, 1,2,4-trichlorobenzene.

Ground Water - Bedrock

Ground-water samples from nine bedrock wells were analyzed for several parameters including VOCs, SVOCs, pesticides, PCBs and inorganic compounds. The chemicals detected were all VOCs, with no SVOCs, pesticides or PCBs detected (see Table 3.3). The levels of inorganics found were determined to be naturally occurring (Section 5.7 of the RI Report).

Eleven of the 17 chemicals detected have been determined to be chemicals of potential concern (Table 3.3). Of the detected chemicals identified in Table 3.3, 1,1,2-trichloroethane, carbon disulfide, chlorobenzene, and chloromethane were eliminated from the chemicals of potential concern on the basis that they were detected only once and at a level below the CRQL. Two other chemicals were eliminated because all detected levels were below the CRQL: 1,1-dichloroethane and toluene.

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TABLE 3.2

CHEMICALS DETECTED IN GROUND WATER - SAPROLITE WELLS
MEDLEY FARM SITE

Chemical	Frequency of Detection	Contract Required Quantitation Limit (ug/kg)	Range of Detected Concentrations (ug/kg)[a]
Volatile Organic Compounds			
*1,1-Dichloroethene	6/14	5	1.1-2200
*1,1-Dichloroethane	2/14	5	38-120
*1,1,1-Trichloroethane	9/14	5	1.5-3400
*1,1,2-Trichloroethane	2/14	5	8-13
*1,2-Dichloroethene (total)	3/14	5	5.4-31
Acetone	1/14	10	7
Benzene	1/14	5	0.7
Bromomethane	3/14	10	1.9-3
Carbon Disulfide	1/14	5	3
Chlorobenzene	1/14	5	0.9
Chloroform	2/14	5	3-4
*Chloromethane	3/14	10	5.5-26
*Methylene Chloride	3/[illegible]	5	2.1-38
*Tetrachloroethene	5/14	5	2-200
Toluene	2/14	5	1-1.5
*Trichloroethene	5/14	5	6-190
Semi-Volatile Organic Compounds			
1,2,4-Trichlorobenzene	1/2	10	3

* Chemical of potential concern

[a] Detected concentrations include estimated results (chemical concentrations less than the contract-required quantitation limit)

TABLE 3.3

CHEMICALS DETECTED IN GROUND WATER - BEDROCK WELLS
MEDLEY FARM SITE

Chemical	Frequency of Detection	Contract Required Quantitation Limit (ug/kg)	Range of Detected Concentrations (ug/kg)[a]
Volatile Organic Compounds			
*1,1-Dichloroethene	6/15	5	2.2-440
1,1-Dichloroethane	2/15	5	2-3
*1,1,1-Trichloroethane	9/15	5	4-310
1,1,2-Trichloroethane	1/15	5	3
*1,2-Dichloroethane	5/15	5	12-290
*1,2-Dichloroethene (total)	2/15	5	2-17
*2-Butanone	4/15	10	6.8-13
*Acetone	3/15	10	1-18
*Benzene	1/15	5	11
Carbon Disulfide	1/15	5	4
Chlorobenzene	1/15	5	1
*Chloroform	6/15	5	4-7
Chloromethane	1/15	10	2
*Methylene Chloride	3/15	5	48-110
*Tetrachloroethene	5/15	5	8-230
Toluene[b]	2/15	5	3-5
*Trichloroethene	5/15	5	140-720
Semi-Volatile Organic Compounds			
None detected			

* Chemical of potential concern

[a]Detected concentrations include estimated results (chemical concentrations less than the contract-required quantitation limit).
[b]Detected concentrations of 5 ug/l is for a diluted sample with a Sample Quantitation Limit of 25 ug/l.

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Surface Water

One surface water sample was collected from each of four locations in Jones Creek and analyzed for VOCs and SVOCs. No VOCs or SVOCs were detected above CRQLs in any of the samples.

Stream Sediments

Four stream sediment samples were collected from Jones Creek, at the same locations as surface water samples, and analyzed for VOCs and SVOCs. No VOCs or SVOCs were detected in stream sediment samples.

3.2.3 Summary of Chemicals of Potential Concern

The primary chemical residuals observed in surface soils at the Site are VOCs, detected above the CRQL in ten of the surface soil samples analyzed for VOCs. VOCs were detected at levels below the CRQL in two other samples. SVOCs were not as widely distributed. They were detected above the CRQL in three samples and below the CRQL in two other samples. PCB-1254 was only detected in three samples and toxaphene in one, in each instance above the CRQL. The extent of site-related chemicals in surface soil is essentially limited to the former disposal area.

Elevated concentrations of VOCs were detected in ground-water samples from 12 of the monitoring wells at the Site; SVOCs, pesticides, and PCBs were not detected above the CRQL. The horizontal extent of site-related chemicals in ground water appears limited to the former disposal areas and immediately downgradient. Vertically, VOCs have been confirmed in the saprolite aquifer as well as the upper bedrock aquifer.

A summary list of the chemicals of potential concern is presented by medium in Table 3.4.

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TABLE 3.4

CHEMICALS OF POTENTIAL CONCERN BY MEDIUM
MEDLEY FARM SITE

	Surface Soil	Ground Water (Saprolite)	Ground Water (Bedrock)
Volatile Organic Compounds			
1,1-Dichloroethene		X	X
1,1-Dichloroethane		X	
1,1,1-Trichloroethane		X	X
1,1,2-Trichloroethane	X	X	
1,1,2,2-Tetrachloroethane	X		
1,2-Dichloroethane			X
1,2-Dichloroethene (total)	X	X	X
1,2-Dichloropropane	X		
2-Butanone			X
Acetone			X
Benzene			X
Chloroform			X
Chloromethane		X	
Ethylbenzene	X		
Methylene Chloride	X	X	X
Styrene	X		
Tetrachloroethene	X	X	X
Trichloroethene	X	X	X
Vinyl Chloride	X		
Semi-Volatile Organic Compounds			
1,2,4-Trichlorobenzene	X		
Butylbenzylphthalate	X		
Di-n-butylphthalate	X		
Di-n-octylphthalate	X		
bis(2-Ethylhexyl)phthalate	X		
Pesticides/PCB			
Toxaphene	X		
PCB-1254	X		

X = Chemical detected in that medium

3.3 HUMAN HEALTH RISK ASSESSMENT

The goal of the human health risk assessment is to characterize the potential exposures at the Site and the potentially exposed populations sufficiently to determine what risks need to be reduced or eliminated and what exposures need to be prevented. The human health risk assessment consists of an exposure assessment, toxicity assessment, and risk characterization.

3.3.1 Exposure Assessment

3.3.1.1 Characterization of Exposure Setting

Physical Setting

A complete description of the physical characteristics of the Medley Farm site is contained in the RI Report and summarized in Section 2.1.

Potentially Exposed Populations - Current Land Use

Current populations that potentially may be exposed to site-related chemicals are residents living in the area surrounding the Medley property and trespassers who may enter the property, including children and hunters. The closest potentially exposed individuals are the property owners, who live approximately 100 feet west of the Site.

The 1980 U.S. Census reported approximately 3,300 persons living within a four-mile radius of the Site; approximately 300 people lived within one mile (SCDHEC, 1988). The city of Gaffney, located five miles to the north, had a reported population of 13,453. There are no signs of current population growth, such as new housing construction, in the Medley Farm area. Preliminary Census figures indicate a 1990 population of 12,670 for the city of

Gaffney, a decrease from the 1980 population. This 1990 figure is considered an incomplete count and as such is not final although these are the best available census data. The preliminary 1990 figure for Cherokee County is 43,071, an increase of almost 3,000 over the 1980 population.

Land use within a four-mile radius of the Site is predominantly rural/residential except for a small, more intensively developed section about 3.5 miles to the north on the outskirts of Gaffney (SCDHEC, 1988). Residential housing consists almost entirely of single-family units. No industrial facilities are located within the four-mile radius. Commercial development is limited to a few small service stations and convenience stores. Two elementary schools are located approximately two miles from the Site, one to the north and one to the west. Commercial agricultural activity in the area consists of forestry and beef cattle production, conducted on a small scale (D. Parker, Clemson University County Extension, personal communication, May 24, 1990). Some local residents also have vegetable gardens. Other local activities include hunting for deer and small game (there is a private hunt club adjacent to the Medley property) and fishing in local perennial streams.

Access to the Site, although not restricted, is limited in that the site is private property surrounded by dense woods; the only access via motorized vehicle is through the Medley driveway. Access on all other sides is protected by steep, heavily wooded ravines. The Site is approximately 600 feet from County Road 72 and visitors must pass directly in front of the Medley property to enter the site.

Sirrine and EPA oversight personnel spent a total of approximately four months at the Site during all seasons of the year and during all hours of the day. In this time, no unauthorized personnel, adults or children, were observed. While this assessment does not preclude the possibility casual visitation, it is evidence that any such visits would be minimal. This observation is consistent with community demographics and the Site setting.

Potential exposures at the Site must consider children (age 1-6) and adults. Visitation of the Site by children is considered to be limited. Access in the winter would be limited by the number of daylight hours following return from school. Access in the summer would be limited by the growth of briars and abundance of ticks evidenced by Sirrine personnel.

Access by adults would be primarily for hunting purposes, although a designated hunting area already exists southwest of the Medley property across Jones Creek. South Carolina law prohibits the discharge of firearms during hunting within 300 yards of a residence. All of the Site is within 300 yards of the Medley residence. The residence or out buildings are clearly visible from the Site. While hunters may occasionally trespass on the Medley property, frequent visits to the Site would be unlikely. State hunting seasons would make any visits seasonal, therefore year-round visitations also are unlikely.

Potentially Exposed Populations - Future Land Use

Residential development was chosen as the future land use for the Site. This is in keeping with USEPA Region IV requirements to evaluate the residential scenario for all sites, except industrial sites located in industrial areas. Residential land use is most often associated with the greatest exposures, and thus is generally the most conservative choice for alternate future land use (U.S. EPA, 1989). The population that potentially may be exposed to site-related chemicals would be any future residents living on-site.

Land in Cherokee County is not zoned and no land use or comprehensive plan has been developed for the county. Appalachian Council of Governments population projections for Cherokee County predict a slow rate of growth, increasing from a 1980 level of 40,093 to 48,400 in the year 2000. Recent development activities in Cherokee County have been concentrated along the I-85 corridor between Spartanburg and Gaffney; residential or industrial growth is not likely to occur in the rural Medley Farm area (S. Cargill, Appalachian Council of Governments, personal communication, May 31, 1990).

Based upon the low population density and slow rate of growth in the Medley Farm Site area and development trends in Cherokee County an alternative future land use scenario was developed in which the Site would remain vacant and the nearest potential residential receptors would be off of the Medley property. This alternative scenario has been developed in order to estimate potential exposures and associated risk levels that would result from use of ground water from a well at the property boundary for drinking water. There would be no contact with site-related chemicals in soil. An exposure assessment and risk characterization for this alternate future land use scenario are presented in Appendix C.

3.3.1.2 Identification of Exposure Pathways

Potential human exposure pathways for the Medley Farm Site have been identified in the context of the current and potential future uses of the site. A complete pathway includes a chemical source/release, retention or transport medium, exposure point, and route of exposure. Two potential human exposure pathways are: exposure to site-related chemicals in ground water and exposure to site soil.

<u>Current Land Use</u>

Human exposure to ground water is of concern under current conditions with respect to its potential use by local residents as drinking water. Potential exposure points are private wells that may be installed downgradient from the Site and off of the property, where ingestion of water would be the route of exposure. There are currently no human receptors for ground water at the property boundary. There are four private domestic water wells within a one mile radius of the Site (Figure 2.4). The closest well, at the Sprouse property across County Road 72, is upgradient from the Site. The remaining three are at least one-half mile from the Site and are not downgradient. Municipal water supply lines serve much of the area, running along all major roads. Based on the above considerations, the ground water pathway is incomplete and was not selected as a means of exposure under current conditions.

For current land use, potential direct contact with site-related chemicals in surface soil is limited to local residents or unauthorized persons (i.e., children or hunters) who could possibly enter the Site. Probable exposure routes are through incidental ingestion and dermal absorption. Particulate inhalation is not considered a probable route of exposure due to the thick vegetative cover at the Site. Off-site exposure to site-related chemicals is considered unlikely due to the vegetative cover at the Site which restricts off-site transfer either by overland runoff or atmospheric transport of soil particles. Exposure due to vaporization of site-related chemicals is considered to be minimal due to low concentration of contaminants in the soil and it will not be considered in the exposure assessment.

Other potential pathways for human exposure to site-related chemicals in surface soil is through the food chain, i.e., vegetation assimilating chemicals from the soil and transferring them to humans or to browsing wildlife. One potential pathway of human exposure is the direct ingestion of blackberries growing at the Site. A second potential pathway of human exposure consists of hunters harvesting and then, along with family members, consuming wildlife that have fed on the Site. Wildlife species that might be hunted and consumed include white-tail deer, rabbits and quail. These species may feed on vegetation that may contain site-related chemicals. Furthermore, burrowing and foraging activities of wildlife may expose wildlife to site-related chemicals through dermal contact. Access to the Site is limited by the fact that the property is privately owned. Potential receptors also are limited due to the sparsely populated rural nature of the area. Furthermore, much of the Site is covered by clean fill thereby limiting potential uptake of site-related chemicals by vegetation. The potential for uptake through these two pathways and resultant risks are considered to be minimal, therefore, these pathways will be qualitatively assessed in Section 3.3.1.5.

Future Land Use 4 9 0031

Human exposure to ground water is of concern in the future residential use scenario with respect to its potential use by future residents of the Site as drinking water. (It should be noted that public drinking water is available at the Site). Potential exposure points are private wells that may be installed on the Site.

The probable exposure routes for future residential contact with site-related chemicals in surface soils are incidental and dermal absorption. Particulate inhalation is not considered a probable route of exposure due to vegetative cover that would be maintained by residents. Exposure due to vaporization of site-related chemicals is considered to be minimal due to low concentrations of contaminants in the soil, and it will not be considered in the exposure assessment or risk characterization.

Exposure Scenarios Not Developed

Other environmental media investigated during the RI - surface water and stream sediments- are not considered potential exposure pathways in this risk assessment because no Site-related chemicals were detected in either medium. They will therefore be excluded from quantitative evaluation.

Summary of Exposure Pathways for Quantitative Evaluation

- exposure to site-related chemicals in ground water via ingestion of drinking water (Future Land Use);
- contact with site-related chemicals in near-surface Site soils through the ingestion and dermal absorption routes (Current and Future Land Uses).

Summary of Exposure Pathways for Qualitative Evaluation

- Exposure to site-related chemicals through the food chain (Current Land Use).

3.3.1.3 Exposure Point Concentrations

The goal of the exposure assessment is the identification of the reasonable maximum exposure for each pathway, in order to estimate a conservative exposure case that is still within the range of possible exposures (reasonable maximum exposure). Exposure point concentrations of the chemicals of potential concern have been quantitatively estimated for surface soil exposure routes and the ground-water route.

Results of sample analyses from RI Site investigations were used to estimate exposure concentrations for the chemicals of concern in ground water and surface soil at the Site. Reasonable maximum exposure was estimated based on the 95 percent upper confidence limit on the arithmetic mean of ground water and surface soil concentrations, in conformance with U.S. EPA (1989). Ground water exposure point concentrations were based on measured concentrations of the chemicals of concern in ground water samples from wells below the Site: SW3, SW4, SW109, BW2, BW105, and BW109. They are presented in Table 3.5. Exposure point concentrations for soil were based on measured concentrations in on-site surface soils samples. Table 3.6 presents the exposure point concentrations for the chemicals of concern in surface soil. A constant concentration over time was assumed, with no consideration of source depletion (a conservative assumption in that the chemicals do degrade over time). It should be noted here that the representative concentrations in Tables 3.5 and 3.6 are less than the maximum detected concentrations shown in Tables 3.1, 3.2 and 3.3. This is due to the fact that the non-detected results were averaged in (at one-half the CRQL) with the detected results for calculation of representative concentrations.

TABLE 3.5

EXPOSURE POINT CONCENTRATIONS - GROUND WATER
MEDLEY FARM SITE

Chemical	Concentration (μg/liter)
1,1-Dichloroethene	1490.60
1,1-Dichloroethane	37.16
1,1,1-Trichloroethane	1636.35
1,1,2-Trichloroethane	5.96
1,2-Dichloroethane	113.66
1,2-Dichloroethene (total)	10.85
Acetone	8.36
Benzene	4.68
2-Butanone	5.79
Chloromethane	7.55
Methylene Chloride	32.68
Tetrachloroethene	107.60
Trichloroethene	327.77

Concentrations are the 95 percent upper confidence limit on the arithmetic average of measured concentrations in ground water wells SW3, SW4, SW109, BW2, BW105, and BW109.

TABLE 3.6

EXPOSURE POINT CONCENTRATIONS - SURFACE SOIL
MEDLEY FARM SITE

Chemical	Concentration (μg/kg)
1,1,2-Trichloroethane	53.7
1,1,2,2-Tetrachloroethane	35.2
1,2-Dichloroethene (Total)	84.1
1,2-Dichloropropane	7.1
Ethylbenzene	10.3
Methylene Chloride	8.4
Styrene	4.6
Tetrachloroethene	28.3
Trichloroethene	25.8
Vinyl Chloride	59.8
1,2,4-Trichlorobenzene	557.9
Butylbenzylphthalate	486.1
Di-n-butylphthalate	397.5
Di-n-octylphthalate	1,696.8
bis (2-Ethylhexyl)phthalate	10,001.1
Toxaphene	164.8
PCB-1254	512.6

Concentrations are the 95 percent upper confidence limit on the arithmetic average of measured concentrations in onsite surface soils.

3.3.1.4 Development of Chemical Intakes

Chemical-specific intakes, or doses, were calculated for the exposure pathways identified for quantitative evaluation in Section 3.3.1.2. The equations used to determine these exposures and the assumptions employed in those equations are presented below, along with a sample calculation for each pathway. A complete listing of the intakes calculated for the chemicals of concern is presented according to pathway in Table 3.7 for current land use and Table 3.8 for future land use.

<u>Current Land Use</u>

Soil Ingestion:

The exposure scenario for soil ingestion is derived below. The intake equation accounts for the difference between adult and child rates of soil ingestion (and is therefore conservative because children typically ingest much more soil than adults). Thus, lifetime exposure is calculated as a weighted average of child and adult exposures, as follows:

$$\underset{\text{(mg/kg/day)}}{\text{Intake}} = \frac{Cs \times IR_c \times FI \times EF_c \times ED_c \times CF}{BW_c \times AT} + \frac{Cs \times IR_a \times FI \times EF_a \times ED_a \times CF}{BW_a \times AT}$$

where:

- Cs = concentration of chemical in soil (mg/kg)
- IR_c = soil ingestion rate for 1 to 6 year old (0.2 g/day)
- FI = fraction ingested from chemical source (.17; site occupies 11% of property x 1.5 = 17% to estimate reasonable worst-case fraction ingested from Site)
- EF_c = frequency of child exposure (24 days per year)
- ED_c = duration of child exposure (6 years)
- BW_c = body weight for 1 to 6 years old (16 kg)
- IR_a = adult ingestion rate (0.1 g/day)

TABLE 3.7
ESTIMATED EXPOSURES BY PATHWAY
CURRENT LAND USE
MEDLEY FARM SITE

Chemical	Reasonable Maximum Daily Dose (mg/kg/day) From Soil Ingestion For Carcinogenic Effects	From Soil Ingestion For Noncarcinogenic Effects	From Dermal Absorption For Carcinogenic Effects	From Dermal Absorption For Noncarcinogenic Effects
1,1 Dichloroethene				
1,1 Dichloroethane				
1,1,1 Trichloroethane				
1,1,2 Trichloroethane	9.4E-10	2.2E-09	7.6E-09	1.8E-08
1,1,2,2-Tetrachloroethane	6.1E-10		5.0E-09	
1,2-Dichloroethane				
1,2-Dichloroethene (total)		3.4E-09		2.8E-08
1,2-Dichloropropane	1.2E-10		1.0E-09	
Acetone				
Benzene				
2-Butanone				
Chloroform				
Chloromethane				
Ethylbenzene		4.2E-10		3.4E-09
Methylene Chloride	1.5E-10	3.4E-10	1.2E-09	2.8E-09
Styrene	8.0E-11	1.9E-10	6.5E-10	1.5E-09
Tetrachloroethene	4.9E-10	1.2E-09	4.0E-09	9.3E-09
Trichloroethene	4.5E-10		3.6E-09	
Vinyl Chloride	1.0E-09		8.4E-09	
1,2,4-Trichlorobenzene		2.3E-08		1.8E-07
Butylbenzylphthalate		2.0E-08		1.6E-07
Di-n-butylphthalate		1.6E-08		1.3E-07
Di-n-octylphthalate		6.9E-08		5.6E-07
bis(2-Ethylhexyl)phthalate	1.7E-07	4.1E-07	1.4E-06	3.3E-06
Toxaphene	2.9E-09		2.3E-08	
PCB	8.9E-09		7.2E-08	

TABLE 3.8
ESTIMATED EXPOSURES BY PATHWAY
FUTURE RESIDENTIAL USE
MEDLEY FARM SITE

	Reasonable Maximum Daily Dose (mg/kg/day)					
	From Groundwater Ingestion		From Soil Ingestion		From Dermal Absorption	
Chemical	For Carcinogenic Effects	For Noncarcinogenic Effects	For Carcinogenic Effects	For Noncarcinogenic Effects	For Carcinogenic Effects	For Noncarcinogenic Effects
1,1 Dichloroethene	1.8E-02	4.3E-02				
1,1 Dichloroethane		1.1E-03				
1,1,1 Trichloroethane		4.7E-02				
1,1,2 Trichloroethane	7.3E-05	1.7E-04	5.1E-08	1.2E-07	1.2E-07	2.7E-07
1,1,2,2-Tetrachloroethane			3.3E-08		7.6E-08	
1,2-Dichloroethane	1.4E-03					
1,2-Dichloroethene (total)		3.1E-04		1.8E-07		4.2E-07
1,2-Dichloropropane			6.7E-09		1.5E-08	
Acetone		2.4E-04				
Benzene	5.7E-04					
2-Butanone		1.7E-04				
Chloromethane	9.2E-05					
Ethylbenzene				2.3E-08		5.2E-08
Methylene Chloride	4.0E-04	9.3E-04	7.9E-09	1.8E-08	1.8E-08	4.2E-08
Styrene			4.3E-09	1.0E-08	9.9E-09	2.3E-08
Tetrachloroethene	1.3E-03	3.1E-03	2.70E-08	6.2E-08	6.1E-08	1.4E-07
Trichloroethene	4.0E-03		2.40E-08		5.5E-08	
Vinyl Chloride			5.6E-08		1.3E-07	
1,2,4-Trichlorobenzene				1.2E-06		2.8E-06
Butylbenzylphthalate				1.1E-06		2.4E-06
Di-n-butylphthalate				8.7E-07		2.0E-06
Di-n-octylphthalate				3.7E-06		8.5E-06
bis(2-Ethylhexyl)phthalate			9.4E-06	2.2E-05	2.2E-05	5.0E-05
Toxaphene			1.6E-07		3.5E-07	
PCB			4.8E-07		1.1E-06	

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EF_a = frequency of adult exposure (24 days per year)

ED_a = duration of adult exposure (24 years; assumes 30 years at one residence, with 6 years spent as a child)

BW_a = adult body weight (70 kg)

CF = conversion factor (10^{-3}kg/g)

AT = averaging time (pathway specific period of exposure: 25,550 for carcinogens; 10,950 days for non-carcinogens)

The reasonable maximum exposure estimate is based on the 95 percent upper bound surface soil concentration at the Site, a child ingestion rate of 0.2 g/day, and an adult ingestion rate of 0.1 g/day. The value used for FI (fraction ingested from chemical source) was derived by multiplying the fraction of the Medley property occupied by the Site (.11) by a factor of 1.5 to estimate a reasonable worst-case for the proportion of contaminated soil (.17) that a trespasser would come into contact with while on the Medley property.

The reasonable conservative estimate of exposure frequency of two days per month, or 24 days per year, was developed based on the site-specific factors presented in Section 3.3.1.1, Potentially Exposed Populations, and summarized here. The Site setting naturally precludes access by casual visitors. Sirrine and EPA oversight personnel spent a total of approximately four months at the Site during all seasons and times of day without observing any unauthorized persons. Access by children is unlikely based on the travel distance required, speed of traffic in the area, and physical attributes of the Site (briars, ticks). Access by adults while hunting is limited by the proximity of the Site to the Medley residence (within 300 yards) which precludes the discharge of firearms.

Below is a sample soil ingestion intake calculation for methylene chloride (for carcinogenic effects):

Intake from soil ingestion =

$$\frac{(8.4\text{E-3 mg/kg})(0.2\text{ g/d})(.17)(24\text{ d})(6\text{ yr})(10^{-3})}{(16\text{ kg})\ (25{,}550\text{ days})} + \frac{(8.4\text{E-3 mg/kg})(0.1\text{ g/d})(.17)(24\text{ d})(24\text{ yr})(10^{-3})}{(70\text{ kg})\ (25{,}550\text{ days})}$$

$$= \frac{4.113\text{E-5}}{4.088\text{E+5}} + \frac{8.225\text{E-5}}{1.789\text{E+6}}$$

$$= 1.47\text{E-10 mg/kg/day}$$

Dermal Absorption:

Exposure due to skin absorption of Site-related chemicals from surface soil also is calculated separately for children and adults, based mainly upon the different dermal absorption factors for these two groups. That is, children are assumed to have a higher dermal absorption factor than adults (0.036 versus 0.018). The reasonable maximum daily dose, calculated as a weighted average of child and adult exposures, is calculated using the following equation:

Absorbed Dose (mg/kg/day) =

$$\frac{Cs \times SA_c \times AF \times ABS_c \times EF_c \times ED_c \times CF}{BW_c \times AT} + \frac{Cs \times SA_a \times AF \times ABS_a \times EF_a \times ED_a \times CF}{BW_a \times AT}$$

where:

- Cs = concentration of chemical in soil (mg/kg)
- SA_c = child exposed surface area (4046 cm^2/event, U.S. EPA, 1990a)
- AF = soil to skin adherence factor (2.11 mg/cm^2, U.S. EPA, 1988c)
- ABS_c = child skin absorption factor (0.036 = 24% direct application absorption rate x 15% matrix effect)(Hawley, 1985)
- EF_c = frequency of child exposure (24 day/year)

ED_c = duration of child exposure (15 years)

BW_c = body weight for 6 to 15 years old (37 kg)

SA_a = adult exposed surface area (3160 cm^2/event, U.S. EPA, 1990a)

ABS_a = adult skin absorption factor (0.018 = 12% direct application absorption rate x 15% matrix effect)(Hawley, 1985)

EF_a = frequency of adult exposure (24 days/year)

ED_a = duration of adult exposure (15 years)

BW_a = adult body weight (70 kg)

AT = averaging time (25,550 days for carcinogens; 10,950 days for non-carcinogens)

CF = conversion factor (10^{-6} kg/mg)

As in the soil ingestion scenario, the 95 percent upper bound surface soil concentration is used as the representative concentration. The exposure factors used in the scenario are based on conservative estimates of soil to skin adherence, skin absorption, and frequency and duration of exposure. Skin surface areas used are 50th percentile values for the body parts representing the reasonable worst case: head, hands, forearms, and lower legs for children, and head, hands, and forearms for adults. Exposure frequency is based upon the factors discussed previously for soil ingestion.

The dermal absorption calculation for methylene chloride for carcinogenic effects from exposure to soil is presented below:

Dose from dermal absorption =

$$\frac{(8.4\text{E-}3\ \text{mg/kg})(4046\ \text{cm}^2\text{/event})(2.11\ \text{mg/cm}^2)(0.036)(24\ \text{events/yr})(15\ \text{yr})(10^{-6})}{(37\ \text{kg})(25{,}550\ \text{days})} +$$

$$\frac{(8.4\text{E-}3\ \text{mg/kg})(3160\ \text{cm}^2\text{/event})(2.11\ \text{mg/cm}^2)(0.018)(24\ \text{events/yr})(15\ \text{yr})(10^{-6})}{(70\ \text{kg})(25{,}550\ \text{days})}$$

$$= \frac{9.294\text{E-}4}{9.454\text{E+}5} + \frac{3.629\text{E-}4}{1.789\text{E+}6}$$

$$= 1.19\text{E-}9\ \text{mg/kg/day}$$

Future Land Use

Ground-water Ingestion:

Exposure due to the drinking water pathway is calculated by:

$$\text{Intake (mg/kg/day)} = \frac{Cw \times IR \times EF \times ED}{BW \times AT}$$

where:

Cw	=	concentration of chemical in water (mg/l)
IR	=	adult ingestion rate (2 l/day for reasonable maximum exposure, U.S. EPA, 1990a)
EF	=	exposure frequency (365 days/year)
ED	=	exposure duration (30 year lifetime)
BW	=	adult body weight (70 kg)
AT	=	averaging time (pathway specific period of exposure: 70 years x 365 days/year or 25,550 days for carcinogens; 30 years x 365 days/year or 10,950 days for non-carcinogens)

The reasonable maximum exposure is represented by the 95 percent upper bound ground-water concentration at the Site and an adult ingestion rate of 2 l/day. An exposure period of 30 years is used, which represents the national upper-bound number of years spent by individuals at one residence (U.S. EPA, 1990a). In keeping with current EPA guidance (U.S. EPA, 1989), the averaging time used for carcinogens is the 70 year standard human lifetime and, for non-carcinogens, it is the applicable exposure duration, in this case 30 years. This difference in averaging time relates to the different mechanisms of action for carcinogens and non-carcinogens, based on the assumption that a higher dose of a carcinogen received over a shorter period of time is equivalent to a corresponding lower dose spread over a lifetime (U.S. EPA, 1989).

A sample calculation for intake through ingestion of ground water is presented below for methylene chloride (for carcinogenic effects):

$$\text{Intake from drinking water ingestion} = \frac{(3.27E\text{-}2\ mg/l)(2\ l/day)(365\ days/yr)(30\ yr)}{(70\ kg)\ (25{,}550\ days)}$$

$$= 4.00E\text{-}4\ mg/kg/day$$

Soil Ingestion:

The intake equation for soil ingestion under the future residential land use scenario is the same as that used for the current land use scenario, with one exception. The fraction ingested from chemical source (FI) has been subdivided into FI_c for children and FI_a for adults. These two factors are based on the different amounts of time children and adults spend at home, either inside or outside, and the proportion of household dust or outdoor soil containing site-related chemicals that they contact during that time. The assumptions made in deriving these FI factors are defined below:

FI_c = fraction ingested by child from chemical source (0.64; Soil containing site-related chemicals comprises 80% of household dust; Hawley, 1985. 100% of soil outside contains site-related chemicals. Child spends 64% of day indoors at home and 13% of day outdoors at home; U.S. EPA, 1990a.)

FI_a = fraction ingested by adult from chemical source (0.52; Soil containing site-related chemicals comprises 80% of household dust; Hawley, 1985. 100% of soil outside contains site-related chemicals. Adult spends 62% of day indoors at home and 2% of day outdoors at home; U.S. EPA, 1990a.)

The only other exposure factor altered is exposure frequency. In order to represent a year-round residential exposure, exposure frequency was increased to 365 days per year for children and adults.

Dermal Absorption:

The intake equation for residential dermal absorption is the same as that used for trespassers under the current land use scenario. One exposure factor was changed: the frequency of exposure was increased to 365 days per year to reflect residential exposure.

3.3.1.5 Qualitative Evaluation of Food Chain Exposure

Exposure to Site-related chemicals in surface soil via the food chain pathways (ingestion of blackberries and wildlife potentially containing site-related chemicals) is considered a possible route of chemical intake at the Medley Farm Site under the current land use scenario. Due to a number of factors, the potential chemical intakes from these pathways are not considered significant. The Site is on private property in a sparsely populated area, thus limiting access for the harvesting of blackberries and also limiting the potential number of persons who would be in the vicinity of the Site. Deer, the wildlife species most likely to be consumed by humans, probably do not feed exclusively on the Site but browse for food over a large area. Much of the Site has been covered by clean fill, and plants growing on, and wildlife foraging and burrowing on, clean fill should not take up site-related chemicals.

3.3.2 Toxicity Assessment

An overview of the toxicity of the chemicals of concern is given in this section. Toxicity profiles that more completely characterize the health effects of these chemicals, as well as their environmental fate and behavior in biological systems, are provided in Appendix D.

3.3.2.1 Carcinogens

Of the 26 chemicals of concern identified in Section 3.2.3, 18 are classified as carcinogens by the EPA. The EPA classification system, based on the strength of evidence that a chemical is a human carcinogen, places each chemical into one of the following classes: A - sufficient human evidence; B1 - limited human evidence but sufficient animal evidence; B2 - inadequate human evidence but sufficient evidence in animals (both considered probable carcinogens); C - no evidence in humans and limited evidence in animals; D - no adequate data (non-classifiable); E -evidence of non-carcinogenicity. Table 3.9 summarizes the carcinogenicity classifications for the chemicals of concern. Only one chemical, vinyl chloride, is Class A (U.S. EPA, 1990c).

The EPA's Carcinogen Assessment Group calculates slope factors, estimates of the excess cancer risk due to continuous exposure to a chemical throughout the course of a 70 year lifetime, for suspected carcinogens. Slope factors for 16 of the 18 chemicals of concern that are carcinogens are shown in Table 3.9. Two of them, 1,1-dichloroethane and butylbenzylphthalate, do not currently have verified slope factors. They are both in Class C, exhibiting no evidence of carcinogenicity in humans and only limited evidence in animals.

3.3.2.2 Non-carcinogens

The primary toxic effects of most of the non-carcinogenic compounds of concern occur in the liver and/or kidneys, often combined with central nervous system depression. There is limited toxicity data available for 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane, and 1,2-dichloroethene.

Reference doses (RfDs) developed by the EPA are estimates of the daily dose of a chemical to which humans, including sensitive subpopulations, can be exposed without an appreciable risk of deleterious effects during a lifetime. The basis of an RfD is usually the

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TABLE 3.9

TOXICITY VALUES: CARCINOGENIC EFFECTS
CHEMICALS OF CONCERN
MEDLEY FARM SITE

Chemical	Oral Slope Factor $(mg/kg/day)^{-1}$	Weight-of Evidence Classification	Source
1,1-Dichloroethene	6.0E-1	C	IRIS
1,1-Dichloroethane	(a)	C	IRIS
1,1,1-Trichloroethane	–	D	IRIS
1,1,2-Trichloroethane	5.7E-2	C	IRIS
1,1,2,2-Tetrachloroethane	2.0E-1	C	IRIS
1,2-Dichloroethane	9.1E-2	B2	IRIS
1,2-Dichloroethene (total)	(b)		IRIS
1,2-Dichloropropane	6.8E-2(a)	B2	HEAST
Acetone	–	D	IRIS
Benzene	2.9E-2	A	IRIS
2-Butanone	–	D	IRIS
Chloroform	6.1E-3	B2	IRIS
Chloromethane	1.3E-2	C	HEAST
Ethylbenzene	–	D	IRIS
Methylene Chloride	7.5E-3	B2	IRIS
Styrene	3.0E-2(a)	B2	HEAST
Tetrachloroethene	5.1E-2(a)	B2	HEAST
Trichloroethene	1.1E-2	B2	HEAST
Vinyl Chloride	2.3E+0	A	HEAST
1,2,4-Trichlorobenzene	–	D	IRIS
Butylbenzylphthalate	ND	C	IRIS
Di-n-butylphthalate	–	D	IRIS
Di-n-octylphthalate	(b)		IRIS
bis(2-Ethylhexyl)phthalate	1.4E-2	B2	IRIS

TABLE 3.9 (CONTINUED)

TOXICITY VALUES: CARCINOGENIC EFFECTS
CHEMICALS OF CONCERN
MEDLEY FARM SITE

Chemical	Oral Slope Factor $(mg/kg/day)^{-1}$	Weight-of Evidence Classification	Source
Toxaphene	1.1E+0	B2	IRIS
PCBs	7.7E+0	B2	IRIS

(a) - Evaluation under review by EPA CRAVE Workgroup
(b) - Not evaluated by EPA
ND - Not determined
IRIS - Integrated Risk Information System (U.S. EPA, 1990c)
HEAST - Health Effects Assessment Summary Tables (U.S. EPA, 1990b)

highest level tested in animal experiments at which no adverse effects were demonstrated (NOAEL, or No Observed Adverse Effect Level). The NOAEL is divided by uncertainty and modifying factors to obtain an RfD. Verified RfDs, which have been peer reviewed and accepted by the EPA, are shown in Table 3.10 for the chemicals of concern. Verified RfDs are available for all but seven of these chemicals. RfDs for 1,1,2,2-tetrachloroethane and trichloroethene are currently being developed, while 1,2-dichloroethane, 1,2-dichloropropane, vinyl chloride, toxaphene, and PCBs have not yet been evaluated by EPA for non-carcinogenic effects.

3.3.3 Risk Characterization

Potential human health risks due to reasonable maximum exposure have been estimated for each chemical of concern. Carcinogenic and non-carcinogenic effects were calculated separately. Non-carcinogenic effects of carcinogenic compounds were included in the calculation of the non-carcinogenic hazard index when appropriate reference doses were available.

3.3.3.1 Carcinogenic Risks

The incremental probability of an individual developing cancer over a lifetime exposure was calculated for the 18 chemicals of concern, classified as carcinogens, by means of the following equation:

Risk = Chronic Daily Intake x Slope Factor

It should be noted here that the slope factor is the upper 95th percentile confidence limit estimate of human risk extrapolated from the multistage model dose-response curve and that chronic daily intake is based on reasonable maximum exposure (95 percent upper confidence limit on the arithmetic mean). Therefore, this equation results in a conservative estimate of carcinogenic risk.

TABLE 3.10

TOXICITY VALUES: NONCARCINOGENIC EFFECTS
CHEMICALS OF CONCERN
MEDLEY FARM SITE

Chemical	Chronic Oral RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty and Modifying Factors	Source
1,1-Dichloroethene	9E-3	Medium	Liver effects	UF=1000 for H,A,L MF = 1	IRIS
1,1-Dichloroethane	1E-1			UFxMF = 1000	HEAST
1,1,1-Trichloroethane	9E-2	Low to Medium	Growth retardation	UF=1000 for H,A,S MF=1	IRIS
1,1,2-Trichloroethane	4E-3	Medium	Liver and immunologic effects	UF=1000 for A,S MF=1	IRIS
1,1,2,2-Tetrachloroethane	(a)				IRIS
1,2-Dichloroethane	(b)				IRIS
1,2-Dichloroethene	2E-2		Hematologic effects	UFxMF=100	HEAST
1,2-Dichloropropane	(b)				HEAST
Acetone	1E-1	Low	Liver and kidney effects	UF=1000 for A, S MF=1	IRIS
Benzene	(a)				IRIS
2-Butanone	5E-2	Medium	Fetotoxicity	UF=1000 for A, S MF=1	IRIS
Chloroform	1E-2	Medium	Liver and reproductive effects	UF=1000 for H,A,L MF=1	IRIS
Chloromethane	(b)				

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TABLE 3.10 (CONTINUED)

TOXICITY VALUES: NONCARCINOGENIC EFFECTS
CHEMICALS OF CONCERN
MEDLEY FARM SITE

Chemical	Chronic Oral RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty and Modifying Factors	Source
Ethylbenzene	1E-1	Low	Liver and kidney effects	UF=1000 for A, S MF=1	IRIS
Methylene Chloride	6E-2	Medium	Liver effects	UF=100 for A MF=1	IRIS
Styrene	2E-1	Medium	Hematologic and liver effects	UF=1000 for A,S	IRIS
Tetrachloroethene	1E-2	Medium	Hepatic effects	UF=1000 forA,S MF=1	IRIS
Trichloroethene	(a)				IRIS
Vinyl Chloride	(b)				IRIS
1,2,4-Trichlorobenzene	2E-2(c)		Liver effects	UF x MF=1000	HEAST
Butylbenzylphthalate	2E-1	Low	Liver effects	UF=1000 for A,S MF=1	IRIS
Di-n-butylphthalate	1E-1	Low	Increased mortality	UF=1000 for H, A, S MF=1	IRIS
Di-n-octylphthalate	2E-2		Liver and kidney effects	UF x MF=1000	HEAST
bis(2Ethylhexyl) phthalate	2E-2	Medium	Liver effects	UF=1000 for H,A,S,L MF=1	IRIS

TABLE 3.10 (CONTINUED)

TOXICITY VALUES: NONCARCINOGENIC EFFECTS
CHEMICALS OF CONCERN
MEDLEY FARM SITE

Chemical	Chronic Oral RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty and Modifying Factors	Source
Toxaphene	(b)				IRIS
PCBs	(b)				IRIS

(a) - Under review by EPA
(b) - Not evaluated by EPA
(c)-Withdrawn from IRIS pending further review
Uncertainty Adjustments: H = variation in human sensitivity
A = animal to human extrapolation
S = extrapolation from subchronic to chronic NOAEL
L = extrapolation from LOAEL to NOAEL
IRIS - Integrated Risk Information System (U.S. EPA, 1990c)
HEAST - Heatlh Effects Assessment Summary Tables (U.S. EPA, 1990b)

The oral slope factor was used to calculate risk for the ground-water and soil ingestion pathways, and an adjusted oral slope factor was used for the soil dermal absorption pathway. Exposures via the soil dermal absorption pathway were calculated and expressed as absorbed doses, therefore the oral slope factors, based on administered dose, were adjusted so that they were also expressed as an absorbed dose.

Chemical-specific risks for the compounds of concern are presented according to pathway in Table 3.11 for the current land use and Table 3.12 for future land use. The total carcinogenic risk in each pathway was calculated by summing the carcinogenic risks posed by each of the carcinogens in that pathway (Total Pathway Risk, Tables 3.11 and 3.12). This method of adding risks, recommended by EPA in its Guidelines for the Health Risk Assessment of Chemical Mixtures (U.S. EPA, 1986), may be overly conservative in that the slope factors, as an upper 95th percentile estimate of potency, are not strictly additive.

Current Land Use

The total estimated carcinogenic risk due to soil ingestion under the current land use scenario is 7.7×10^{-8}. For dermal absorption of chemicals in soil, the total carcinogenic health risk is 7.8×10^{-7}. These risk levels are less than the EPA remediation goals of 10^{-4} to 10^{-6} risk levels.

In order to estimate the total risk to which an individual may be exposed, reasonable exposure pathway combinations must be identified. At the Medley Farm Site, it is reasonable to assume that under current conditions an individual might be exposed via both identified pathways: coming into direct contact with Site soils through ingestion and through dermal absorption. This total upper bound risk, shown as the final summation in Table 3.11, is 8.6×10^{-7} (or a chance of 8.6 excess cancers in a population of 10,000,000 over a 70-year period).

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TABLE 3.11
RISK CHARACTERIZATION: CARCINOGENIC EFFECTS
CURRENT LAND USE
MEDLEY FARM SITE

Chemical	CDI (mg/kg/day)	Slope Factor (a) (mg/kg/day)-1	Chemical-specific Risk
Exposure Pathway: Soil Ingestion			
1,1,2-Trichloroethane	9.4E-10	5.7E-2	5.3E-11
1,1,2,2-Tetrachloroethane	6.1E-10	2.0E-1	1.2E-10
1,2-Dichloropropane	1.2E-10	6.8E-2	8.4E-12
Methylene Chloride	1.5E-10	7.5E-3	1.1E-12
Styrene	8.0E-11	3.0E-2	2.4E-12
Tetrachloroethene	4.9E-10	5.1E-2	2.5E-11
Trichloroethene	4.5E-10	1.1E-2	4.9E-12
Vinyl Chloride	1.0E-9	2.3E+0	2.4E-9
bis(2-Ethylhexyl) phthalate	1.7E-7	1.4E-2	2.4E-9
Toxaphene	2.9E-9	1.1E+0	3.2E-9
PCB	8.9E-9	7.7E+0	6.9E-8
		Total Pathway Risk	7.7E-8

TABLE 3.11 (CONTINUED)
RISK CHARACTERIZATION: CARCINOGENIC EFFECTS
CURRENT LAND USE
MEDLEY FARM SITE

Chemical	CDI (mg/kg/day)	Slope Factor (a) (mg/kg/day)-1	Chemical-specific Risk
Exposure Pathway: Dermal Absorption of Soil (a)			
1,1,2-Trichloroethane	7.6E-9	7.1E-2	5.4E-10
1,1,2,2-Tetrachloroethane	5.0E-9	4.0E+0	2.0E-8
1,2-Dichloropropane	1.0E-9	7.2E-2	7.2E-11
Methylene Chloride	1.2E-9	1.7E-2	2.0E-11
Styrene	6.5E-10	3.3E-2	2.1E-11
Tetrachloroethene	4.0E-9	1.7E-1	6.8E-10
Trichloroethene	3.6E-9	2.2E-1	8.0E-10
Vinyl Chloride	8.4E-9	2.3E+0	2.0E-8
bis(2-Ethylhexyl) phthalate	1.4E-6	1.6E-2	2.3E-8
Toxaphene	2.3E-8	1.6E+0	3.8E-8
PCB	7.2E-8	9.4E+0	6.8E-7
		Total Pathway Risk	7.8E-7
	TOTAL EXPOSURE RISK		8.6E-7

(a) Slope factors for dermal absorption have been adjusted from an administered to an absorbed dose.

TABLE 3.12
RISK CHARACTERIZATION: CARCINOGENIC EFFECTS
FUTURE RESIDENTIAL USE
MEDLEY FARM SITE

Chemical	CDI (mg/kg/day)	Slope Factor (a) (mg/kg/day)-1	Chemical-specific Risk
Exposure Pathway: Ingestion of Ground Water			
1,1-Dichloroethene	1.8E-2	6.0E-1	1.1E-2
1,1,2-Trichloroethane	7.3E-5	5.7E-2	4.2E-6
1,2-Dichloroethane	1.4E-3	9.1E-2	1.3E-4
Benzene	5.7E-5	2.9E-2	1.7E-6
Chloromethane	9.2E-5	1.3E-2	1.2E-6
Methylene Chloride	4.0E-4	7.5E-3	3.0E-6
Tetrachloroethene	1.3E-3	5.1E-2	6.7E-5
Trichloroethene	4.0E-3	1.1E-2	4.4E-5
		Total Pathway Risk	1.1E-2
Exposure Pathway: Soil Ingestion			
1,1,2-Trichloroethane	5.1E-8	5.7E-2	2.9E-9
1,1,2,2-Tetrachloroethane	3.3E-8	2.0E-1	6.6E-9
1,2-Dichloropropane	6.7E-9	6.8E-2	4.5E-10
Methylene Chloride	7.9E-9	7.5E-3	5.9E-11
Styrene	4.3E-9	3.0E-2	1.3E-10
Tetrachloroethene	2.7E-8	5.1E-2	1.4E-9
Trichloroethene	2.4E-8	1.1E-2	2.7E-10
Vinyl Chloride	5.6E-8	2.3E+0	1.3E-7
bis(2-Ethylhexyl) phthalate	9.4E-6	1.4E-2	1.3E-7
Toxaphene	1.6E-7	1.1E+0	1.7E-7
PCB	4.8E-7	7.7E+0	3.7E-6
		Total Pathway Risk	4.2E-6

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TABLE 3.12 (CONTINUED)
RISK CHARACTERIZATION: CARCINOGENIC EFFECTS
FUTURE RESIDENTIAL USE
MEDLEY FARM SITE

Chemical	CDI (mg/kg/day)	Slope Factor (a) (mg/kg/day)-1	Chemical-specific Risk
Exposure Pathway: Dermal Absorption of Soil (a)			
1,1,2-Trichloroethane	1.2E-7	7.1E-2	8.2E-9
1,1,2,2-Tetrachloroethane	7.6E-8	4.0E+0	3.0E-7
1,2-Dichloropropane	1.5E-8	7.2E-2	1.1E-9
Methylene Chloride	1.8E-8	1.7E-2	3.1E-10
Styrene	9.9E-9	3.3E-2	3.3E-10
Tetrachloroethene	6.1E-8	1.7E-1	1.0E-8
Trichloroethene	5.5E-8	2.2E-1	1.2E-8
Vinyl Chloride	1.3E-7	2.3E+0	3.0E-7
bis(2-Ethylhexyl) phthalate	2.2E-5	1.6E-2	3.4E-7
Toxaphene	3.5E-7	1.6E+0	5.8E-7
PCB	1.1E-6	9.4E+0	1.0E-5
		Total Pathway Risk	1.2E-5
	TOTAL EXPOSURE RISK		1.1E-2

(a) Slope factors for dermal absorption have been adjusted from an administered to an absorbed dose.

Future Land Use

The reasonable maximum carcinogenic risk for ingestion of ground water is estimated to be 1.1×10^{-2} for the future residential use scenario. Total estimated carcinogenic risk due to soil ingestion is 4.2×10^{-6}. For dermal absorption of chemicals in soil, the total carcinogenic health risk is 1.2×10^{-5}. Risks from soil exposure are within the EPA remediation goal of 1×10^{-4} to 1×10^{-6} risk.

For the future residential use scenario at the Medley Farm Site, it is reasonable to assume that an individual resident might be exposed via all identified pathways: drinking ground water, and coming into direct contact with Site soils through ingestion and dermal absorption. this total upper bound risk, shown as the final summation in Table 3.12 is 1.1×10^{-2}. This risk is driven by the ground-water ingestion pathway.

3.3.3.2 Non-carcinogenic Effects

The potential for non-carcinogenic toxicity to occur in an exposed individual is evaluated by comparing the exposure level with a reference dose, as follows:

Hazard Quotient = Chronic Daily Intake/Reference Dose

If the hazard quotient is less than one, it is unlikely that even sensitive populations would experience adverse health effects. If the quotient exceeds unity, however, there may be concern for potential non-carcinogenic effects (U.S. EPA, 1989).

The risk characterizations for non-carcinogenic effects are summarized in Table 3.13 for current land use and Table 3.14 for future land use. To assess the overall potential for non-carcinogenic effects posed by exposure to multiple chemicals, a hazard index equal to the

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TABLE 3.13
RISK CHARACTERIZATION: NONCARCINOGENIC EFFECTS
CURRENT LAND USE
MEDLEY FARM SITE

Chemical	CDI (mg/kg/day)	RfD (a) (mg/kg/day)	Hazard Quotient
Exposure Pathway: Soil Ingestion			
1,1,2-Trichloroethane	2.2E-9	4E-3	5.5E-7
1,2-Dichloroethene (total)	3.4E-9	2E-2	1.7E-7
Ethylbenzene	4.2E-10	1E-1	4.2E-9
Methylene Chloride	3.4E-10	6E-2	5.7E-9
Styrene	1.9E-10	2E-1	9.4E-10
Tetrachloroethene	1.2E-9	1E-2	1.2E-7
1,2,4-Trichlorobenzene	2.3E-8	2E-2	1.1E-6
Butylbenzylphthalate	2.0E-8	2E-1	9.9E-8
Di-n-butylphthalate	1.6E-8	1E-1	1.6E-7
Di-n-octylphthalate	6.9E-8	2E-2	3.5E-6
bis(2-Ethylhexyl) phthalate	4.1E-7	2E-2	2.0E-5
		Pathway Hazard Index	2.6E-5

TABLE 3.13 (CONTINUED)
RISK CHARACTERIZATION: NONCARCINOGENIC EFFECTS
CURRENT LAND USE
MEDLEY FARM SITE

Chemical	CDI (mg/kg/day)	RfD (a) (mg/kg/day)	Hazard Quotient
Exposure Pathway: Dermal Absorption of Soil (a)			
1,1,2-Trichloroethane	1.8E-8	3.2E-3	5.5E-6
1,2-Dichloroethene (total)	2.8E-8	1.0E-3	2.8E-5
Ethylbenzene	3.4E-9	8.4E-2	4.1E-8
Methylene Chloride	2.8E-9	2.7E-2	1.0E-7
Styrene	1.5E-9	1.8E-1	8.2E-9
Tetrachloroethene	9.3E-9	3.0E-3	3.1E-6
1,2,4-Trichlorobenzene	1.8E-7	1.9E-2	9.7E-6
Butylbenzylphthalate	1.6E-7	1.7E-1	9.6E-7
Di-n-butylphthalate	1.3E-7	1.0E-1	1.3E-6
Di-n-octylphthalate	5.6E-7	1.8E-2	3.1E-5
bis(2-Ethylhexyl) phthalate	3.3E-6	1.8E-2	1.8E-4
		Pathway Hazard Index	2.6E-4
		TOTAL EXPOSURE HAZARD INDEX	2.9E-4

(a) Slope factors for dermal absorption have been adjusted from an administered to an absorbed dose.

TABLE 3.14
RISK CHARACTERIZATION: NONCARCINOGENIC EFFECTS
FUTURE RESIDENTIAL USE
MEDLEY FARM SITE

Chemical	CDI (mg/kg/day)	RfD (a) (mg/kg/day)	Hazard Quotient
Exposure Pathway: Ingestion of Ground Water			
1,1-Dichloroethene	4.3E-2	9E-3	4.7E+0
1,1-Dichloroethane	1.1E-3	1E-1	1.1E-2
1,1,1-Trichloroethane	4.7E-2	9E-2	5.2E-1
1,1,2-Trichloroethane	1.7E-4	4E-3	4.3E-2
1,2-Dichloroethene (total)	3.1E-4	2E-2	1.6E-2
Acetone	2.4E-4	1E-1	2.4E-3
2-Butanone	1.7E-4	5E-2	3.3E-3
Methylene Chloride	9.3E-4	6E-2	1.6E-2
Tetrachloroethene	3.1E-3	1E-2	3.1E-1
		Pathway Hazard Index	5.6E+0
Exposure Pathway: Soil Ingestion			
1,1,2-Trichloroethane	1.2E-7	4E-3	2.9E-5
1,2-Dichloroethene (total)	1.8E-7	2E-2	9.2E-6
Ethylbenzene	2.3E-8	1E-1	2.3E-7
Methylene Chloride	1.8E-8	6E-2	3.1E-7
Styrene	1.0E-8	2E-1	5.0E-8
Tetrachloroethene	6.2E-8	1E-2	6.2E-6
1,2,4-Trichlorobenzene	1.2E-6	2E-2	6.1E-5
Butylbenzylphthalate	1.1E-6	2E-1	5.3E-6
Di-n-butylphthalate	8.7E-7	1E-1	8.7E-6
Di-n-octylphthalate	3.7E-6	2E-2	1.9E-4
bis(2-Ethylhexyl) phthalate	2.2E-5	2E-2	1.1E-3
		Pathway Hazard Index	1.4E-3

TABLE 3.14 (CONTINUED)
RISK CHARACTERIZATION: NONCARCINOGENIC EFFECTS
FUTURE RESIDENTIAL USE
MEDLEY FARM SITE

Chemical	CDI (mg/kg/day)	RfD (a) (mg/kg/day)	Hazard Quotient
Exposure Pathway: Dermal Absorption of Soil (a)			
1,1,2-Trichloroethane	2.7E-7	3.2E-3	8.4E-5
1,2-Dichloroethene (total)	4.2E-7	1.0E-3	4.2E-4
Ethylbenzene	5.2E-8	8.4E-2	6.1E-7
Methylene Chloride	4.2E-8	2.7E-2	1.6E-6
Styrene	2.3E-8	1.8E-1	1.3E-7
Tetrachloroethene	1.4E-7	3.0E-3	4.7E-5
1,2,4-Trichlorobenzene	2.8E-6	1.9E-2	1.5E-4
Butylbenzylphthalate	2.4E-6	1.7E-1	1.5E-5
Di-n-butylphthalate	2.0E-6	1.0E-1	2.0E-5
Di-n-octylphthalate	8.5E-6	1.8E-2	4.7E-4
bis(2-Ethylhexyl) phthalate	5.0E-5	1.8E-2	2.8E-3
		Pathway Hazard Index	4.0E-3
	TOTAL EXPOSURE HAZARD INDEX		5.6E+0

(a) Slope factors for dermal absorption have been adjusted from an administered to an absorbed dose.

sum of the hazard quotients was calculated (in accordance with U.S. EPA, 1986) for each pathway. As with the hazard quotient, if the hazard index exceeds unity there may be concern for potential adverse health effects.

Current Land Use

Neither of the hazard indices for the two exposure pathways exceeds unity. Adding the hazard indices for both pathways for exposure to Site-related chemicals yields a total hazard index of 2.9×10^{-4}. This sum is approximately four orders of magnitude below unity, the EPA hazard quotient level that would indicate a potential for adverse effect. Thus there is no concern for potential non-carcinogenic health effects under the current land use scenario.

Future Land Use

Adding the hazard indices for all the pathways for exposure to Site-related chemicals yields a total hazard index of 5.6 for the future residential use scenario. Ingestion of ground water is responsible for all of the non-carcinogenic hazard. Hazard indices for soil ingestion (1.4×10^{-3}) and dermal absorption from soil (4.0×10^{-3}) are both less than one, indicating no concern for potential health effects due to exposure to on-site soil.

3.3.3.3 Discussion of Uncertainty

The estimates of human health risks developed in this risk assessment required a considerable number of assumptions about exposure and subsequent adverse human health effects.

Most of the site-specific uncertainties are included in the exposure assessment (Section 3.3.1). In the calculation of chemical intake, it was necessary to estimate numerous parameter values for use in the intake equations, in particular: exposure frequencies for contact with Site soil, and soil adherence and absorption factors for dermal absorption of site-related chemicals. Uncertainty associated with the toxicity values presented in the toxicity assessment (Section 3.3.2) is summarized in Tables 3.9 and 3.10. Two of the carcinogens identified in soil or ground water lack slope factors and nine of the chemicals lack reference doses. Without toxicity factors, these chemicals cannot be included in the quantitative evaluation of risk.

Only two of the chemicals of potential concern, benzene and vinyl chloride, are Class A (known) carcinogens. Benzene was found only in ground water at low concentrations and was responsible for a minor portion (1.7×10^{-6}) of the risk due to ground-water ingestion for future residential use of the Site. Vinyl chloride, found in surface soil, was not a major contributor to risk from ingestion and dermal absorption for either land use scenario. The chemical that contributed most to the estimate of cancer risk through the ground-water ingestion pathway was 1,1-dichloroethene. This chemical, however, with a weight-of-evidence classification of C, has not shown evidence of carcinogenicity in humans and only limited evidence in animals.

In order to account for the fact that the intake from dermal absorption represents an absorbed rather than an administered dose, adjustments were made to the toxicity factors used to estimate risk and hazard. These adjustments were based on an estimate of oral absorption efficiency (applied to the oral slope factor or RfD). Due to lack of available data on oral absorption efficiency for some of the chemicals, a conservative assumption of oral absorption efficiency of 5% was assumed for four of the six carcinogens and for four of the nine chemicals evaluated for non-carcinogenic effects.

3.3.3.4 Summary of Human Health Risk

The exposure pathways quantitatively evaluated in this baseline risk assessment for the Medley Farm Site are those considered to be the most likely and significant routes of human exposure to site-related chemicals.

Current Land Use

There is no significant carcinogenic risk due to exposure to site-related chemicals under current land use conditions. The cumulative carcinogenic risks at the Site are estimated to be 8.6×10^{-7}. This risk is below the NCP risk level of 10^{-6} used as a point of departure for determining remediation goals for known or suspected carcinogens. Acceptable exposure levels are generally those that represent an excess upper bound lifetime cancer risk of between 10^{-4} and 10^{-6}. Cumulative carcinogenic risks at the Site are therefore not significant under current land use.

The risk level from soils is based primarily on the contribution of PCB-1254, which accounts for 7.5×10^{-7} of the total soil-related risk. PCB-1254 was detected at only three of the surface soil sampling locations (HA3, HA8, HA11). Therefore, most of the carcinogenic risk at the Site is derived from a limited area of potential exposure and is therefore considered to overestimate potential risk. Considering the scattered and infrequent nature of PCB detections in surface soil and the fact that the PCB risk level is below the EPA remediation goal of 10^{-4} to 10^{-6}, PCB in surface soil is not considered to pose a significant carcinogenic risk to exposed individuals.

No significant risk due to non-carcinogenic effects of site-related chemicals has been identified under current land use conditions. Total non-carcinogenic hazard is estimated to be 2.9×10^{-4}, which is below unity, the EPA hazard quotient level that would indicate a potential for adverse effect.

The food chain pathways were qualitatively evaluated. Any potential risk due to ingestion of blackberries or wildlife possibly containing site-related chemicals taken up from Site soils is considered to be minimal, based on the fact that:

1) much of the Site has been covered by clean fill, and plants growing on clean fill should not take up Site-related chemicals,
2) the Site is on private property, thus limiting access to people who might harvest the blackberries and wildlife,
3) the Site is surrounded by ravines and dense hardwood forest, further limiting access,
4) deer, the species most likely to be potentially harvested and consumed, probably do not feed exclusively on the Site.

Future Land Use

For the future on-site residential use scenario, estimated carcinogenic risk due to exposure to site-related chemicals is 1.1×10^{-2} for all pathways combined. Virtually all of the risk is from ingestion of ground water. The risk level from contact with soil is 4.2×10^{-6} for soil ingestion and 1.2×10^{-5} for dermal absorption of chemicals in soil, within the EPA remediation level goals of 10^{-4} to 10^{-6}. As in the current land use scenario, the risk from soil is based primarily on the contribution of PCB-1254, which accounts for 1.4×10^{-5} of the soil-related risk. As previously discussed under Current Land Use, this risk is derived from a limited area for potential exposure.

The total non-carcinogenic hazard for future residential use of the Site is estimated to be 5.6. Ingestion of ground water is responsible for all of the non-carcinogenic hazard. Hazard indices for soil ingestion, 1.4×10^{-3}, and dermal contact with soil, 4.0×10^{-3}, are both less than one, indicating no concern for potential health effects due to residential exposure to on-site soil.

Risks were estimated for the alternative future land use scenario described in Section 3.3.1.1 (see Appendix C). Potential carcinogenic risks for exposure to site-related chemicals in ground water were estimated for a hypothetical private well located at the property boundary. Estimated carcinogenic risks for this pathway are 5.5×10^{-5}, within the 1×10^{-4} to 1×10^{-6} risk range of EPA remediation goals.

3.4 ENVIRONMENTAL ENDANGERMENT ASSESSMENT

3.4.1 Exposure Assessment

Exposure to ground water and soils containing site-related chemicals are potential sources of environmental endangerment. As stated in previous sections, exposure to ground water on the Site is not a pathway of concern because the ground water plume containing site-related chemicals is presently confined to the Site and no exposure points exist. The potential for endangerment of the flora and fauna of Jones Creek, the stream along the eastern end of the property, could exist if ground water containing site-related chemicals entered this stream. However, no site-related chemicals were detected in the stream water samples, the sediment samples, or the monitoring wells closest to Jones Creek.

Because much of the Site has been covered with clean fill and is covered with vegetation, exposure of terrestrial animals to soil by dermal contact and ingestion is considered unlikely. Ingestion of plants potentially containing site-related chemicals is minimized because of the clean fill covering much of the Site. For species with large home ranges (e.g. deer), ingestion of plants growing on the Site will represent only a portion of their diets, thus further minimizing their intake of site-related chemicals.

3.4.2 Risk Characterization

Characterization of risk for the ground-water pathway is not pursued further because there are no exposure points on the Site, and the RI revealed no site-related chemicals in the stream sediment or water column. The potential risks are due to exposure to chemicals through soil contact and through ingestion of plants that may absorb these chemicals. Potential risk due to contact with soils is reduced because much of the Site is covered with clean fill. Plants growing on the clean fill should not take up site-related chemicals, thereby limiting any potential risk from ingestion of vegetation on the site. For species with large home ranges (e.g. deer), potential risk is further reduced because contact with site soils is reduced and site-related plants represent only a portion of their diets.

3.5 SUMMARY

There is no significant carcinogenic risk due to exposure to site-related chemicals at the Medley Farm Site under current land use conditions. The cumulative carcinogenic risk is estimated to be 8.6×10^{-7} due to soil ingestion and dermal absorption of soil. This risk level would not pose a significant carcinogenic risk from exposure to Site chemical residuals and is less than the EPA remedial goals of 1×10^{-4} to 1×10^{-6} risk. Based on a total pathway hazard index of 2.9×10^{-4}, the Site would pose no public health concerns for non-carcinogenic effects due to exposure to Site chemical residuals. No potential for significant risk to wildlife populations on or adjacent to the Site has been identified.

For the future on-site residential use scenario, estimated carcinogenic risk due to exposure to site-related chemicals is 1.1×10^{-2} for all pathways combined. Virtually all of the risk is from the potential future ingestion of ground water. The chemical responsible for most of the estimated carcinogenic risk due to ground-water ingestion, 1,1-dichloroethene, has a weight-of-evidence classification (confidence level) of C, which means that there is no evidence of carcinogenicity in humans and only limited evidence in animals. The risk level from contact with soil is 1.6×10^{-5}, within the EPA remediation level goals of 1×10^{-4} to 1×10^{-6} risk. Total noncarcinogenic hazard for future residential use of the Site is estimated to be 5.6, due entirely to ground-water ingestion.

4.0 REMEDIAL RESPONSE OBJECTIVES

Site-specific remedial response objectives are based on the baseline risk assessments presented in Section 3 and on the evaluation of applicable or relevant and appropriate requirements (ARARs). Results of the risk assessments and the evaluations of ARARs will be used to define potential areas of remediation at the Medley Farm Site.

4.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

Section 121(d) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that remedial actions comply with requirements or standards set forth under Federal and State environmental laws. The requirements that must be complied with are those that are applicable or relevant and appropriate to the location, the potential remedial actions, and the media-specific chemicals at the site. As mandated by CERCLA 121(d)(2)(A), remedies must consider "any promulgated standard, requirements, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation" if the former is applicable or relevant and appropriate to the site and associated remedial activities. SARA requires that the remedial action for a site meet all ARARs unless one of the following conditions is satisfied:

- the remedial action is an interim measure where the final remedy will attain the ARAR upon completion;
- compliance will result in greater risk to human health and the environment than other options;
- compliance is technically impracticable;
- an alternative remedial action will attain the equivalent of the ARAR;

- for State requirements, the State has not consistently applied the requirement in similar circumstances.

ARARs may be classified as either action-specific, location-specific or chemical-specific. Review of ARARs with respect to the Medley Farm Site is given in the following subsections.

4.1.1 Action-specific ARARs

Action-specific requirements set controls or restrictions on the design, performance and other aspects of implementation of specific remedial activities. Examples include RCRA regulations for off-site disposal of hazardous residuals and Clean Water Act standards for discharge of treated ground water. Since action specific ARARs apply to discrete remedial activities, their evaluation is presented in Section 7, Detailed Analysis of Alternatives, for each retained alternative. A retained alternative must conform to all ARARs unless one of the five statutory waivers stated above is involved.

CERCLA Section 121(e) exempts any on-site response action from having to obtain a Federal, State and/or local permit. The on-site actions must still comply with the substantive aspects of these requirements, however.

4.1.2 Location-specific ARARs

Location-specific ARARs must consider Federal, State, and local requirements that reflect the physiographical and environmental characteristics of the site or the immediate area. Remedial actions may be restricted or precluded depending on the location or characteristics of the site and the resulting requirements. A listing of potential location-specific ARARs and their consideration in the Feasibility Study is given in Table 4.1.

TABLE 4.1
POTENTIAL LOCATION - SPECIFIC ARARs
MEDLEY FARM SITE

SITE FEATURE/LOCATION	CITATION	REQUIREMENT SYNOPSIS	CONSIDERATION IN THIS FS
		FEDERAL	
Within 61 meters (200 feet) of a fault displaced in Honocene time	40 CFR 264.18(a)	New treatment, storage, or disposal of hazardous waste prohibited; applies to RCRA hazardous waste; treatment, storage, or disposal.	Not an ARAR since Site is not within 200 feet of a fault displaced in Honocone time.
Within 100-year flood plain	40 CFR 264.18(b)	Facility must be designed, constructed, operated, and maintained to avoid washout; applies to RCRA hazardous waste; treatment, stored, or disposal.	Not an ARAR since Site is not in a 100-year flood plain.
Within flood plain	Protection of floodplains (40 CFR 6, Appendix A); Fish and Wildlife Coordination Act (16 USC 661 et seq.); 40 CFR 6.302; Flood plains Executive Order (EO 11988)	Action to avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values; applies to action that will occur in a flood plain, i.e., lowlands, and relatively flat areas adjoining inland and coastal waters and other flood prone areas.	Not an ARAR since Site is not in a flood plain.
Within area where action may cause irreparable harm, loss or destruction of significant artifacts	National Historical Preservation Act (16 USC Section 469); 36 CFR Part 65	Requires that action be taken to recover and preserve artifacts when alteration of terrain threatens significant scientific, prehistorical, historical, or archaeological data.	Not an ARAR since Site is not a designated archaeological area.

TABLE 4.1 (CONTINUED)
POTENTIAL LOCATION - SPECIFIC ARARs

SITE FEATURE/LOCATION	CITATION	REQUIREMENT SYNOPSIS	CONSIDERATION IN THIS FS
Critical habitat upon which endangered species or threatened species depends	Endangered Species Act of 1973 (16 USC 1531 et seq.); 50 CFR Part 200, 50 CFR Part 402; Fish and Wildlife Coordination Act (16 USC 661 et seq.); 33 CFR Parts 320-330	If endangered or threatened species are present, action must be taken to conserve endangered or threatened species, including consultation with the Department of Interior.	Not an ARAR since Site does not have endangered or threatened species.
Wetlands	Clean Water Act Section 404; 40 CFR Part 230, 33 CFR Parts 320-330	For wetlands as defined by U.S. Army Corps of Engineers regulations, must take action to prohibit discharge of dredged or fill material into wetlands without permit.	Not an ARAR since Site is not in a wetlands are and no bodies of water or wetlands are to be modified.
	40 CFR Part 6, Appendix A	For action involving construction of facilities or management of property in wetlands (as defined by 40 CFR Part 6, Appendix A, section 4(j)), action must be taken to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.	Not an ARAR since Site is not in a wetlands area.
Wilderness area	Wilderness Act (16 USC 1131 et seq.); 50 CFR 35.1 et seq.	For Federally-owned area designated as wilderness area, the area must be administered in such manner as will leave it unimpared as wilderness and to preserve its wilderness.	Not an ARAR since Site is not in a wilderness area.
Within area affecting national wild, scenic, or recreational river	Wild and Scenic Rivers Act (16 USC 1271 et seq.); section 7 (a)); 40 CFR 6.302(e)	For activities that affect or may affect any of the rivers specified in section 1271(a), must avoid taking or assisting in action that will have direct adverse effect on scenic river.	Not an ARAR since Site is not on or near a scenic river.

TABLE 4.1 (CONTINUED)
POTENTIAL LOCATION - SPECIFIC ARARs

SITE FEATURE/LOCATION	CITATION	REQUIREMENT SYNOPSIS	CONSIDERATION IN THIS FS
Classification and potential use of an aquifer	* Guidelines for Ground Water Classification, EPA Ground Water Protection Strategy. (USEPA, 1984; USEPA, 1986)	Consider Federal and State aquifer classifications in the assessment of remedial response objectives.	TBC since drinking water wells have been installed and used in the vicinity of the Site. Note that this is not an ARAR but is USEPA policy and therefore falls into the category of other criteria or guidelines to be considered (TBC).
	STATE		
Within 100-year flood plain	S.C. R.61.264.18 (b)	Facility located within a 100-year flood plain must be designed, constructed, and maintained to permit washout of any waste materials.	Not an ARAR since Site is not in a 100-year flood plain.
Wetlands	S.C. Pollution Control Act	Facility must not be located in a wetland.	Not an ARAR since Site is not in a wetlands area.

Federal and State aquifer classifications must be considered in the assessment of remedial response objectives. The classification and potential uses of an aquifer are important elements in determining appropriate remediation levels. Under EPA's ground water classification system, the ground water beneath the Site is considered Class IIA (current source of drinking water) even though there are no downgradient receptors in the immediate area. The State of South Carolina considers all ground water to be Class GB (current source of drinking water) with the exception of exceptionally valuable waters (GA) or waters naturally unsuitable for potable purposes (GC). Ground water must be irreplaceable, with no reasonable alternative source of drinking water available, or vital to a particularly sensitive ecological system to be considered Class GA. Ground water at the Site is therefore Class GB.

Jones Creek is Class B under South Carolina classifications. The 7Q10 flow (weekly low flow rate over a ten year period) for Jones Creek is estimated from a runoff coefficient of 0.19 cfs/sq. mile (DHEC, 1990) and a drainage area of 2.5 square miles to be approximately 0.5 cubic feet per second (200 gallons per minute).

4.1.3 C nical-specific ARARs

Chemical-specific ARARs are concentration limits in the environment promulgated by government agencies. Health-based site-specific levels must be developed for chemicals or media where such limits do not exist. Potential chemical-specific ARARs are discussed by media below.

4.1.3.1 Ground Water

Site ground water is considered a current source of drinking water under Federal guidelines (Class IIA) and as Class GB under State guidelines. The NCP states that Maximum Contaminant Levels (MCLs), established under the Safe Drinking Water Act (SDWA), are potentially relevant and appropriate ground-water standards for the remediation of current or potential sources of drinking water (300.430(e)(2)(i)(A)). South Carolina quality standards for Class GB ground waters are the MCLs given in the State Primary Drinking Water Regulations (R.61-58.5 D.(2)). Where MCLs have not been promulgated, SARA requires the use of other relevant and appropriate health-based levels to establish potential ground water remediation levels.

The most stringent of the available Federal and State of South Carolina drinking water standards are presented for each Site chemical detected in ground water above SQLs in Table 4.2 along with the corresponding maximum concentration detected in ground-water samples analyzed during the RI. Comparison of these standards with concentrations detected in samples collected from the Site shows that concentrations of certain VOCs in ground water at the Site exceed MCLs. The Federal and State standards included on Table 4.2 are based on the use of ground water as a source of drinking water and therefore represent the most conservative potential remediation levels for ground water at the Site.

Alternate Concentration Limits (ACLs) were considered for application at the Medley Site as an option in lieu of otherwise applicable requirements or limitations. ACLs may be used when it can be demonstrated that all potentially contaminated ground water has known or projected points of discharge into surface water and no statistically significant increase of contaminant concentrations will occur in the surface water into which the ground water discharges (SARA, 1986). ACLs should only be used, however, if there is no significant degradation of uncontaminated ground water before discharge to surface water occurs. EPA policy also specifies that the provision for ACLs be used only when cleanup to ARARs is not practicable (EPA, 1988).

Contaminants from the Site were not detected in surface water samples collected from Jones Creek, or its tributaries, during the RI. Ground water along the eastern boundary of the Medley Site discharges into Jones Creek, and is monitored by wells BW-3 and BW-4. Based upon measurement of surface water levels in the creek at stream staff gauges SL1 and SL2, information on the saturated thickness of the water-bearing zone (bedrock/saprolite system), and ground-water elevations from adjacent wells PZ-1, BW-3 and BW-4, it cannot be demonstrated that all contaminated ground water from the Site would

TABLE 4.2

POTENTIAL GROUND-WATER REMEDIATION LEVELS
MEDLEY FARM SITE

Compound	Maximum Conc. (ug/L)	Well	Remediation Level (ug/L)	Source
Acetone	18	BW2	350	(1)
Benzene	11	BW105	5	MCL
2-Butanone	13	BW106	2000	(2)
Chloromethane	26	BW108	63	(1)
Chloroform	10	BW2	100	MCL
1,1-Dichloroethane	120	SW4	350	(1)
1,2-Dichloroethane	290	BW2	5	MCL
1,1-Dichloroethene	2200	SW4	7	MCL
1,2-Dichloroethene	31	SW4	cis: 70	MCL
			trans: 100	MCL
Methylene Chloride	110	BW2	5	pMCL
Tetrachloroethene	200	SW3	5	MCL
1,1,1-Trichloroethane	3400	SW4	200	MCL
1,1,2-Trichloroethane	18	BW4	5	pMCL
Trichloroethene	720	BW2	5	MCL

MCL = Safe Drinking Water Act Maximum Contaminant Level
(40 CFR Parts 141.61)

(1) Remediation level derived in Appendix E.

(2) Proposed RCRA Corrective Action Level (55 FR 30798)

pMCL = Proposed Maximum Contaminant Level
(55 FR 30370)

NA - Not available

discharge into the creek along this boundary. The use of ACLs is, therefore, not appropriate for application at the Medley Site and will not be further evaluated.

4.1.3.2 Surficial Soils

The only promulgated Federal or State standards for contaminants detected in surface soil are the Toxic Substances Control Act (TSCA) cleanup levels for PCBs (40 CFR 761.125). For areas of unrestricted access, TSCA specifies a cleanup level for PCBs of 10 mg/kg when there are 10 inches of overlying clean fill. This level has been applied at other CERCLA sites in Region IV (Chemtronics Site, Swannanoa, NC). Concentrations of PCBs detected in samples of site soils were all well below 10 mg/kg. PCB levels at the Site are therefore in compliance with ARARs. To confirm the appropriateness of the TSCA level, a health-based level was developed for the Site using the Preliminary Pollutant Limit Value (PPLV) approach (Appendix E). A surficial soil remediation level of 5.5 mg/kg was established for PCBs based on ingestion and dermal absorption. Concentrations of PCBs detected in all surface soil samples analyzed during the RI were also below 5.5 mg/kg.

There are no promulgated Federal or State standards for concentrations of any of the other contaminants detected in surface soils at the Site. Remediation levels, if appropriate, would therefore be developed on a site-specific basis using a health-based exposure analysis considering potential direct human exposure pathways. The baseline risk assessment considered such pathways and determined that the cumulative chemical concentrations of surficial soils at the Site do not pose a significant risk to human health. Concentrations of individual chemicals therefore could not present significant risks. Specific remediation levels for surficial soils have therefore not been developed.

4.1.3.3 Subsurface Soils

Remediation levels for subsurface soils are based on a compound's potential to impact ground water. While only VOCs were detected in ground water, both VOCs and SVOCs were detected in subsurface soils. Accordingly, subsurface soil remediation levels will be developed for VOCs and SVOCs to be conservative. Based on the following discussion and the unsaturated transport modeling in Appendix F, however, only VOCs have the potential to impact ground water above protective standards.

Concentrations of chemicals in subsurface soil, that are protective of ground water were developed using a leaching model considering Site infiltration, equilibrium chemical partitioning, ground water ARARs, and mixing of infiltration with ground water. Modeling assumptions and equations are presented in Appendix F. Volatile organics are the only site-related compounds detected in ground water. Calculated concentrations of volatile organics in subsurface soils that would be protective of Site ground water to MCLs are presented in Table 4.3 along with a tabulation of soil boring and test pit locations where these soil remediation levels were exceeded. Sampling locations are presented in Figure 2.5.

Two of the sampling locations where volatile organics exceed the calculated remediation levels are considered to be a minimal risk to ground water based on site-specific conditions. 1,2-Dichloroethane was detected in SB-7 in the 5-7 foot range at a concentration of 97 ug/kg, which slightly exceeds the remediation level of 60 ug/kg. Samples collected at SB-7 in the 15-17 and 25-27 foot intervals contained no 1,2-dichloroethane, indicating no vertical migration and no threat to ground water. A similar situation exists at SB-3. Methylene chloride was detected there in the 10-12 foot range at 50 ug/kg, which slightly exceeds the remediation level of 40 ug/kg. Underlying samples collected at the 15-17 and 25-27 foot intervals at SB-3 contained no methylene chloride. Accordingly, soils at locations SB-3 and SB-7 represent a minimal risk to ground water and will not be considered for remediation.

Acetone concentrations at the site also represent a minimal risk to ground water. Acetone has such a high mobility (Koc = 2.2 ml/g) that it would be expected to move through the soil column rapidly and have been detected at significant concentrations in ground water. That acetone has only been detected in ground water at low concentrations (18 ug/l) illustrates a limitation of the use of Koc in estimating contaminant transport rates in the

TABLE 4.3

POTENTIAL VOLATILE ORGANIC SOIL REMEDIATION LEVELS
MEDLEY FARM SITE

Compound	Soil Remediation Level (ug/kg)	Locations Where Remediation Level Exceeded
Acetone	12,000	(SB2)
1,1-Dichloroethane	100	None
1,2-Dichloroethane	60	TP12, SB4, (SB7), SB9
1,1-Dichloroethene	270	None
1,2-Dichloroethene (total)	2,100	TP3
1,1,1-Trichloroethane	26,000	None
1,1,2-Trichloroethane	160	None
Trichloroethene	500	TP3, TP4
Tetrachloroethene	1,600	TP3, TP4
Chloroform	3,000	None
Methylene chloride	40	TP4, (SB3)

NOTE: Locations given in parentheses are considered a minimal risk to ground water based on site-specific conditions.

Soil remediation levels are derived in Appendix F.

unsaturated zone, and a conservative feature of the model. Koc represents a compound's tendency to partition to organic carbon only (and in a general sense to adsorb to porous surface areas, such as clays) and does not account for any other mechanisms influencing the potential fate of a chemical in the subsurface environment. Acetone has such a high vapor pressure (270 mm Hg @ 25°C) that it would tend to volatize before it could progress significantly through the soil column. Volatilization would explain the low concentrations of acetone in Site ground water in spite of the model's predictions. Based on the assumptions above, acetone levels detected in subsurface soils at the Site are not considered to have the potential to impact ground water above protective levels and will not be considered for remediation. Acetone levels in ground water are significantly below their remediation level (3500 ug/l).

The following semi-volatile organics were detected in subsurface soils above a concentration of 1 mg/kg but were not detected in ground water:

- benzoic acid
- 1,4-dichlorobenzene
- diethylphthalate
- bis(2-ethylhexyl)phthalate
- phenol
- 1,2,4-trichlorobenzene.
- PCBs.

Soil remediation levels for these compounds should also be based on their potential to impact ground water above ARARs. Proposed MCLs exist for bis(2-ethylhexyl)phthalate and 1,2,4-trichlorobenzene (55 FR 30370) and MCLs exist for 1,4-dichlorobenzene and PCBs (40 CFR 141.61). Ground water quality levels for the remaining compounds must be based on health-based risk levels, where available. Oral reference doses (RFD) are used for non-carcinogens while oral cancer potency factors are used for carcinogens. Calculation of ground water quality levels is based on the following EPA factors:

- 70 kg body weight
- 2 liters per day ingestion
- 10^{-6} risk level (carcinogens).

Derivations of protective ground water levels are presented in Appendix E. The resulting ground water standards were then input to the soil leaching model (Appendix F) to derive protective soil remediation levels.

Health-based concentrations for Site related semi-volatile organics in ground water and the resulting soil remediation levels are presented in Table 4.4, along with maximum concentrations of these compounds detected in samples of soil from the Site. The absence of semi-volatile organics in ground water is in good agreement with the calculated soil remediation levels. The only SVOCs with concentrations in subsurface soils exceeding the calculated protective soil level are bis(2-ethylhexyl)phthalate and 1,2,4-trichlorobenzene. The unsaturated transport model predicts that bis(2-ethylhexyl)phthalate (BEHP) and 1,2,4-trichlorobenzene (TCB) will require approximately 190 years to reach ground water beneath the Site at concentrations above MCLs. This result is consistent with the low mobilities of these compounds (Koc > 9000 ml/g) and their absence in Site ground water. Removal mechanisms such as biodegradation and volatilization, which were not considered in the transport model, will be important over a period of 190 years. The half-life of BEHP in water due to biodegradation is approximately 2-3 weeks and there is evidence of biodegradation in soils (Howard, 1989). Based on the unsaturated transport modelling in appendix F, a fifty percent reduction over 190 years would be required to reduce the concentration of BEHP to below the calculated remediation levels. This level of reduction is reasonably achievable and existing BEHP levels are therefore not expected to impact ground water above MCLs.

TABLE 4.4

POTENTIAL SEMIVOLATILE ORGANIC SOIL REMEDIATION LEVELS
MEDLEY FARM SITE

Compound	Ground Water Remediation Level (ug/L)	Soil Remediation Level (ug/kg)	Maximum Site Soil Concentration (ug/kg)
Acenaphthalene	32	210,000	75,000
Benzoic Acid	140,000	5,500,000	37,000
1,4-Dichlorobenzene	75	150,000	2,300
Diethylphthalate	28,000	3,300,000	3,200
Bis(2-ethylhexyl)phthalate	4	84,000	161,000
Phenol	21,000	250,000	94,000
1,2,4-Trichlorobenzene	9	160,000	710,000
PCBs	0.5	400,000	5,400

Soil remediation levels are derived in Appendix F. Ground water remediation levels are MCLs where available, otherwise they are derived in Appendix E.

The half-life of TCB in soils has been measured to be approximately 16 days, primarily due to volatilization (Sims, 1988). An 80 percent reduction over 190 years would be required to achieve the Site soil remediation levels. This is equivalent to a half-life of 88 years, significantly greater than the measured period. While Site conditions may yield a slower removal rate, TCB soil concentrations are expected to decrease significantly through natural mechanisms during this time period and therefore do not present the potential to impact ground water above their MCL.

In summary, the absence of semivolatile organics in ground water is consistent with results of unsaturated transport modeling and environmental fate mechanisms. Based upon analyses performed during the RI, concentrations of semivolatile organics present in subsurface soils at the Site do not have the potential to impact ground water above MCLs and do not require remediation.

4.1.3.4 Surface Waters

The only surface water which receives direct discharge of ground water from beneath the Site is Jones Creek and its' intermittent tributaries immediately NE and SW of the Ralph Medley farm property. Relevant and appropriate requirements for the protection of aquatic organisms are Federal Ambient Water Quality Criteria (AWQC; EPA, 1986). No site-related chemicals were detected in surface water samples collected from Jones Creek during the RI. Site surface waters are therefore in compliance with ARARs.

4.1.3.5 Sediments

There are no promulgated Federal or State quality standards for sediments. No site-related chemicals were detected in sediment samples collected from Jones Creek during the RI. Accordingly, sediment quality criteria are not necessary and will not be derived.

4.2 AREAS OF POTENTIAL REMEDIATION

Site media that pose significant risks to human health and the environment and/or exceed ARARs represent areas of potential remediation. Potential human health and environmental risks were evaluated in Section 3. Potential ARARs and site-specific remediation levels were evaluated in Section 4.1.

4.2.1 Ground Water

The results of the RI and the baseline risk assessment indicate that ground water at the Site presents no current risks to human health or the environment. The baseline risk assessment determined that potential future concentrations of volatile organic contaminants from the Site in ground water at the Ralph Medley farm property line along Jones Creek could pose a risk level of 2.4×10^{-5}, should a drinking water well be established at the property boundary. This risk level is consistent with the acceptable exposure range given by the NCP. While the existing public water supply makes construction of a supply well in this area unlikely, ground water remediation alternatives will be developed on a risk basis as a protective measure.

Concentrations of some volatile organic compounds present in ground water beneath the Site exceed Federal and State MCLs. Ground-water remediation will therefore be considered for compliance with these ARARs. Compliance with MCLs can be evaluated for existing ground-water conditions and for potential receptors of ground water from the Site. The evaluation of existing conditions would be based upon all ground water impacted by the Site that currently exceeds MCLs. Since these criteria are based on human ingestion of ground water, a more appropriate evaluation of remediation requirements would be based upon a potential point of exposure. There are currently no known existing exposure points to contaminated ground water from the Site. The baseline human health assessment determined that the closest point of potential exposure in the future would be at the Site, although there are currently no potable water wells located there. Jones Creek approximates the Medley Farm property line on the eastern boundary. Ground-water extraction modeling was performed considering the following existing and projected situations:

- extraction and treatment (as necessary) of all ground water from the Site with concentrations of VOCs exceeding MCLs (Option 1);
- extraction and treatment (as necessary) of ground water at the Site such that future concentrations could not exceed MCLs at the potential exposure point, i.e. Jones Creek (Option 2).

The results of the modeling of these extraction options is presented in Appendix B and summarized in Section 4.3.1. These options can be combined into one extraction alternative that will satisfy both regulatory goals. Retained ground-water remediation alternatives therefore include two potential extraction systems:

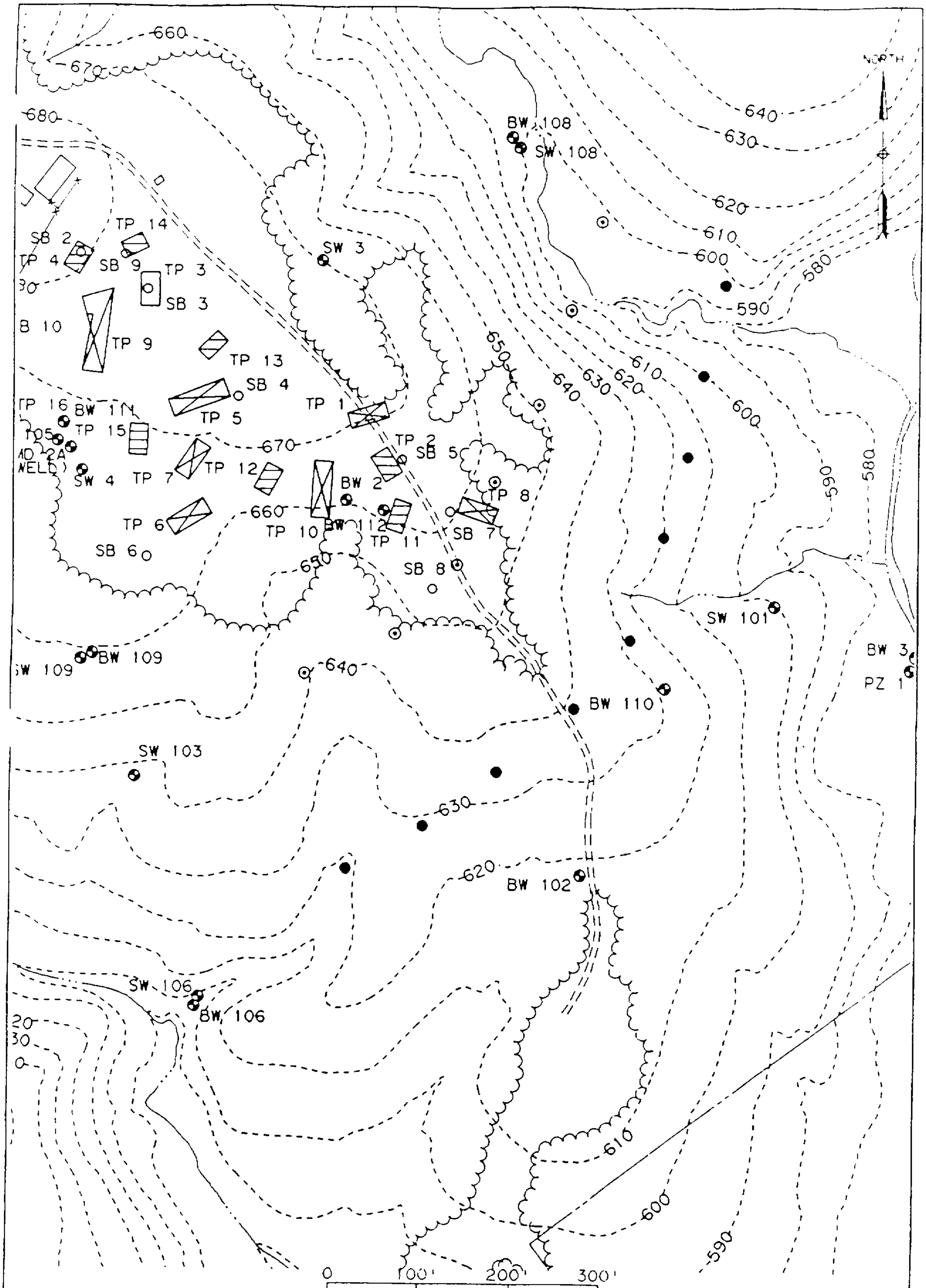
•Extraction System 1: Recover all Site ground water exceeding MCLs (total flow of 30 gpm)

•Extraction System 2: Recover all Site ground water such that MCLs are met at the property line (total flow of 15 gpm).

Locations of wells for the proposed extraction systems are depicted in Figure 4.1.

4.2.2 Soils

The baseline risk assessment determined that surficial soils and vegetation at the Site pose no significant risks to human health or the environment. The only promulgated Federal or State standard for levels of Site-related contaminants present in soils at the Site is the TSCA level for PCBs. Analyses performed during the RI indicate that concentrations of PCBs



● OPTION 1 EXTRACTION WELLS

⊙ OPTION 2 EXTRACTION WELLS

SIRRINE ENVIRONMENTAL CONSULTANTS

Greenville, South Carolina

FIGURE 4.1
POTENTIAL GROUNDWATER RECOVERY SCHEMES
MEDLEY FARM SITE

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CAD FILE NO. ZFA1:1110.007(FIGURE42.DGN

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present in soils at the Site are well below the TSCA level of 10 mg/kg. Remediation of surficial soils is therefore not required on a health basis or for direct compliance with ARARs. The absence of contaminants at concentrations which present significant risk in surficial soils at the Site is likely due in part to the removal of contaminated soils and waste materials during the immediate removal action.

The potential need for remediation of subsurface soils is based upon a compound's ability to migrate and thereby impact ground water at concentrations exceeding ground-water ARARs through leaching. The RI data and subsequent modeling indicate that volatile organics are the only compounds present in soils at the Site with the potential to impact ground water at concentrations exceeding ARARs. Sampling locations where concentrations of VOCs exceeded the conservative remediation levels for soils developed in Section 4.1.3.3 are presented in Table 4.5 along with the estimated surface area and depth of contaminated soils with each location. For sampling locations where the chemical for concern was present throughout the sampled interval and was also detected in ground water above MCLs, the depth of contamination is assumed to be equal to that of the unsaturated soils column. For sampling locations associated with a former lagoon or disposal area, the areal extent of significant contamination is estimated from surrounding sampling locations and the aerial photos taken prior to the removal action (SCDHEC, 1989).

Discrete areas of potential soil remediation are numbered in Table 4.5. The approximate extent of each of these areas is illustrated on Figure 4.2. Potential soil remediation area 1 (RA-1) consists of the former lagoon and drum area in the northern corner of the Site, an area including TP-4 and SB-9. RA-2 consists of the former lagoon and drum storage area located approximately 90 feet south of RA-1, an area including TP-3. RA-3 consists of the former three lagoons and drum area located approximately 150 feet south of RA-2, an area bracketed by SB4 and TP12.

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TABLE 4.5

POTENTIAL AREAS OF SUBSURFACE SOIL REMEDIATION

Potential Remediation Area (RA)	Associated Sampling Locations	Disposal Area	Area	Depth
1	SB9, TP4	Lagoon, drums	5,000 ft^2	65'
2	TP3	Lagoon, drums	5,000 ft^2	65'
3	SB4/TP12	Lagoons, drums	12,000 ft^2	65'

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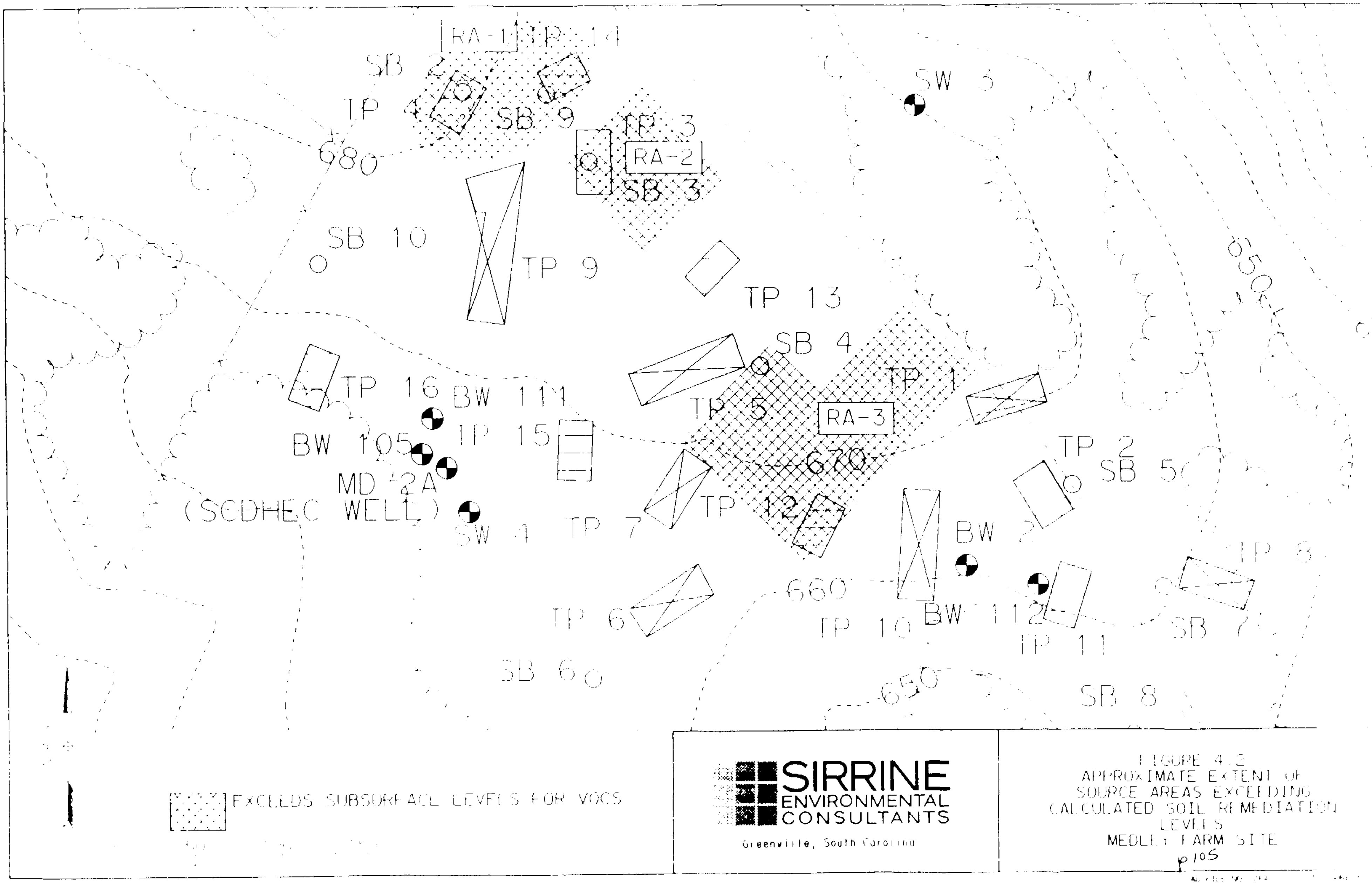

FIGURE 4.2
APPROXIMATE EXTENT OF
SOURCE AREAS EXCEEDING
CALCULATED SOIL REMEDIATION
LEVELS
MEDLEY FARM SITE

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Remedial alternatives will be developed for the specific remediation of these areas. Based on a total area of approximately 22,000 square feet and an unsaturated depth of 65 feet, the total volume of subsurface soils potentially requiring remediation is approximately 53,000 cubic yards.

4.3 REMEDIAL DESIGN BASIS

Identification of the media at the Site potentially requiring remediation and the physical/ chemical properties of contaminants related to former disposal operations at the Site is necessary for the evaluation of potential remedial alternatives. Areas of potential remediation were presented in Section 4.2. Physical/chemical properties relevant to potential remedial technologies are presented below. An assessment of the potential range of anticipated ground-water flow conditions at the time of potential remediation is also presented to help assess the feasibility and design of recovery systems.

4.3.1 Ground-water Modeling

The assessment of potential ground-water recovery technologies at the Site is based upon data gathered from the RI field investigations. A conceptual model of ground-water flow at the Site, based on data generated during the RI, was used to guide the development and analysis of ground water remediation options. The results of ground-water analyses from Phases I and II of the RI were used to determine the distribution and concentrations of contaminants present at the Site. Analytical models describing ground-water flow and hydraulics were used to develop a conceptual design for the location of extraction wells for the two potential ground-water remediation scenarios retained for consideration. Descriptions of the models, input parameters and site-specific assumptions are presented in Appendix B.

Aquifer characteristics described in the previous section on ground-water modeling were used to complete this remedial design analysis. Based on these characteristics, ground-water extraction could require extraction wells operating at pumping rates ranging from 2 to 10 gallons per minute, depending on anticipated variations in aquifer conditions (saturated thickness, transmissivity, and storativity) at each specific extraction well location.

Ground-water extraction wells would be screened in the transition zone between the saprolite and relatively competent bedrock ("transition zone"). This zone generally consists of extremely fractured bedrock with zones of saprolite. Ground water occurring in the saprolite and bedrock at the Site is part of an interconnected aquifer system with vertical gradients being primarily upward. The hydraulic conductivity of the transition zone is greater than that of the saprolite above. Pumping from the transition zone would influence groundwater in the saprolite above and the fractured bedrock below. Due to the higher hydraulic conductivity, the transition zone would tend to be the most likely pathway of contaminant migration and would therefore be an optimal zone for groundwater recovery. Wells would be screened sufficiently into the transition zone to achieve the required capture of bedrock ground water. Capture effectiveness would be confirmed through aquifer response measurements conducted in select wells during construction of the overall extraction system.

Assuming withdrawal of all ground water containing Site-related contaminants above MCLs, the reasonable maximum extraction flow rate would be on the order of 30 gallons per minute. Assuming withdrawal is limited to ground water which contains contaminant concentrations which would be attenuated (via dispersion, adsorption, and degradation) to below MCLs at the property boundary, the total extraction system flow rate is anticipated to be on the order of 15 gallons per minute. The derivation of these extraction rates is presented in Appendix B.

The evaluation of potential ground water treatment technologies must be based on anticipated extraction rates and influent concentrations. The most conservative estimate of influent conditions would be the combination of the maximum flow rate (30 gpm - Option

4 9 0091

1) at the highest individual chemical concentrations detected in ground water at the Site. These conditions are presented in Table 4.6. The resulting mass loadings given on the table are overestimated since the maximum flow would not be associated with maximum concentrations and concentrations of contaminants in ground water will decrease with time. These levels are presented to provide a basis for a conservative estimate of conceptual design requirements.

Transport modeling was conducted to estimate future ground water concentrations at the nearest point of potential exposure for use in Appendix C of the baseline risk assessments (i.e., no action implemented to address the contamination in ground water, as described in Section 3.3.1.3). Projected concentrations for Site VOCs at the Jones Creek property line at ten year increments and corresponding MCLS are presented in Table 4.7. The basis for the modeling is described in Appendix B. Average concentrations over a 70 year period, the average human life span, are also presented in Table 4.7. All of the averaged concentrations are within their respective MCLs. Since MCLs are "at the tap" concentrations meant to be protective over a lifetime of exposure, Site ground water at the property line in the future would conform to SDWA requirements without treatment. Only 1,1-dichloroethene and trichloroethene would exceed their MCLs, and only at the 20 year interval. The discussion of human exposure concentrations is hypothetical since there are no current receptors for Site groundwater and future receptors are unlikely.

4.3.2 Physical Properties of Chemicals

Chemicals present at concentrations exceeding potential ground-water and soil remediation levels are limited to volatile organic compounds (VOCs), as determined in Section 4.1. Physical properties of these compounds relevant to the evaluation of potential treatment technologies are presented in Table 4.8.

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TABLE 4.6

ESTIMATED GROUND WATER INFLUENT
EXTRACTION OPTION 1

Compound	Concentration (ug/l)[1]	Mass (lbs/month)[2]
1,1-Dichloroethane	120	1.3
1,1-Dichloroethene	2,200	24
1,2-Dichloroethane	290	3.1
1,2-Dichloroethene (total)	31	0.3
1,1,1-Trichloroethane	3,400	37
1,1,2-Trichloroethane	18	0.2
Trichloroethene	720	7.8
Tetrachloroethene	200	2.2
Methylene chloride	110	1.2
Chloroform	10	0.1
Total VOCs	7,099	77

1 Based on maximum individual concentrations at the Site. Concentrations will decrease during remediation

2 At a ground water extraction rate of 30 gpm (Extraction Option 1). Mass loadings for Extraction Option 2 (15 gpm) would be 50 percent lower.

TABLE 4.7
MEDLEY FARM SITE
GAFFNEY, SOUTH CAROLINA
AVERAGE GROUND WATER EXPOSURE CONCENTRATIONS AT
PROPERTY BOUNDARY UNDER THE NO ACTION SCENARIO

	YEAR								
COMPOUND	10	20	30	40	50	60	70	30-YEAR AVE	MCL
1,1,1-TRICHLOROETHANE	0.00	18.34	16.74	1.37	0.04	0.00	0.00	11.7	200
1,1-DICHLOROETHENE	0.22	18.53	2.88	0.00	0.00	0.00	0.00	7.2	7
TRICHLOROETHENE	0.00	5.54	2.11	0.11	0.00	0.00	0.00	2.6	5
1,2-DICHLOROETHANE	0.10	2.22	0.22	0.01	0.00	0.00	0.00	0.85	5
TETRACHLOROETHENE	0.00	0.05	1.77	0.94	0.09	0.00	0.00	0.61	5
1,2-DICHLOROETHENE	0.00	0.26	0.04	0.00	0.00	0.00	0.00	0.10	70
1,1,2-TRICHLOROETHANE	0.00	0.11	0.01	0.00	0.00	0.00	0.00	0.04	5
CHLOROFORM	0.00	0.08	0.01	0.00	0.00	0.00	0.00	0.03	100
METHYLENE CHLORIDE	0.11	0.70	0.05	0.00	0.00	0.00	0.00	0.29	5
1,1-DICHLOROETHANE	0.05	0.89	0.08	0.00	0.00	0.00	0.00	0.34	350
BENZENE	0.00	0.01	0.06	0.00	0.00	0.00	0.00	0.02	5

The average period of 30 years is equal to the national upper-bound time (90th percentile) at one residence.

Projected through the average human lifespan of 70 years.

Concentrations are given in ug/l.

MCL values are taken from Table 4.2.

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TABLE 4.8

PHYSICAL PROPERTIES OF VOLATILE ORGANICS AND PCBS

Compound	Hc (dimensionless)	Koc (ml/g)	Aerobic Biodegradation	Anaerobic Biodegradation
1,1-Dichloroethane	0.18	30	N	P
1,1-Dichloroethene	1.41	65	N	P
1,2-Dichloroethane	0.04	14	N	P
cis-1,2-Dichloroethene	0.31	49	N	P
trans-1,2-Dichloroethane	0.27	59	N	P
1,1,1-Trichloroethane	0.60	152	N	P
1,1,2-Trichloroethane	0.05	56	N	P
Trichloroethene	0.38	126	N	P
Tetrachloroethane	1.08	364	N	P
Methylene chloride	0.11	24	Y	P
Chloroform	0.12	31	N	P
PCBs	0.04	530,000	P	P

Notes

Hc - Henry's Law constant
Koc - Organic carbon partitioning coefficient
N - No potential for removal under standard aerobic conditions
Y - Verified removal
P - Possible removal, probably incomplete destruction

References

Hc and Koc data - "Superfund Public Health Evaluation Manual" (EPA, 1986).
Biodegradation data - "Guidance Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Pr~gram" (EPA, 1987).

4.3.3 Physical Properties of Soils

The residual soil at the Site is absent or occurs as a thin, discontinuous layer overlying saprolite. This residual soil layer ranges in thickness from zero to 11 feet and typically consists of clayey silt with varying amounts of fine sand, clay, mica flakes, and quartz gravel. In some area, thin layers of clayey silt/silty clay fill were encountered. Saprolite at the Site ranges from 50 to 70 feet in thickness near the former disposal area and consists predominantly of a silt with varying amounts of fine to coarse sand, clay, mica flakes, and quartz gravel.

From the physical soil analyses (Appendix H of the RI), the average natural water content of soils in the unsaturated zone is approximately 20 percent. Based on evaluation of the sieve analyses and empirical data, the porosity of the unsaturated zone is approximately 30 percent. The bulk density of the soils is assumed to be 1.9 gm/cm^3.

5.0 IDENTIFICATION OF POTENTIAL TECHNOLOGIES

The purpose of this initial screening effort is to identify a thorough list of generally applicable remediation technologies that can be formed into remedial alternatives for the Site. Remedial action technologies evaluated include treatment alternatives, physical controls, and institutional measures that can be used individually or in combination with other technologies to eliminate or control the public health or environmental concerns associated with the Site. The potential remedial measures must be technically feasible considering the Site conditions and the identified chemicals. The specific technologies have been individually screened on the basis of the Site conditions, waste characteristics, and technical requirements to eliminate those technologies that are inapplicable, infeasible, ineffective, insufficiently developed, or otherwise inappropriate. Preliminary cost information has been used to screen out the more costly technologies which do not provide additional remedial effectiveness over those retained. A series of general remedial alternatives has been developed for Site media using retained technologies.

Certain technologies have been retained that may only apply to a discrete portion of a medium but may be useful in forming an overall alternative or disposing of a minor amount of material. Specific technical and institutional requirements regarding implementation of technologies are described more completely in the "Detailed Analysis of Alternatives" (Section 7).

5.1 SCREENING CRITERIA

The National Contingency Plan (NCP) and Superfund Amendments and Reauthorization Act (SARA) provide basic criteria for screening of technologies. The following three basic criteria were established:

- Effectiveness
- Implementability
- Cost

It was necessary during the screening process to identify an adequate number of technologies to allow for an appropriate remedial response to identified media of concern. In some cases, a technology deemed useful in providing either partial treatment or containment has been retained because it could be combined with other retained technologies to produce an effective remedial alternative.

5.1.1 Effectiveness

Technologies must be compatible with the waste and Site conditions and must protect the public health and the environment. To accomplish this they must be effective in reducing or eliminating any short-term and long-term human health or environmental risks directly associated with the Site to appropriate levels. The technology itself must not have adverse impacts on the environment, public health, or public welfare. Technologies for which Site waste characteristics or Site conditions clearly limit their effectiveness at the Site or which do not provide adequate protection of the environment, public health, and public welfare have been eliminated. Technologies which have not demonstrated effectiveness at other similar sites are also eliminated from further consideration.

5.1.2 Implementability

Implementability includes both the technical and institutional feasibility of applying a technology process. Technologies have been evaluated based on the technical feasibility and availability of resources and equipment, and the administrative feasibility of implementing the technology. The nature of the technology should be such that, in the physical setting associated with the Site, it can be implemented in a cost effective and timely manner. In addition, the implementation of the technology should not elicit substantial public concerns in the community. Site accessibility, available area, and potential future use of the property may also affect the implementation of certain technologies. Technologies that are unworkable based on site conditions have been eliminated. Mobilization and permitting requirements, where applicable, must be workable and previously demonstrated at equivalent projects. Preliminary consideration has also been given to regulatory constraints such as handling, disposal, and treatment requirements that will effect the implementation of certain remedial technologies. These considerations will be evaluated further for the retained technologies when action-specific ARARs are developed. Technologies that are not technically or administratively feasible have been removed from further consideration.

5.1.3 Cost

Any technology which delivers similar levels of applicability, effectiveness and implementability as other technologies but which has a significantly greater cost has been eliminated. Technologies that are equivalent in cost but are clearly less effective than other retained technologies also are rejected. Otherwise, cost is not used as a criteria to screen technologies at this point in the process.

5.2 LISTING OF POTENTIAL TECHNOLOGIES

The purpose of this section is to establish a preliminary list of treatment technologies that are potentially applicable based on the considerations outlined in Section 5.1.1. As directed by the NCP, appropriate technologies for the range of general response actions have been considered. The initial list of technologies is based on past experience at other sites, demonstrated technologies at similar hazardous waste sites, a literature review of technical publications, EPA guidance publications and Appendix D of the NCP. A list of potential treatment technologies was developed to address the areas of potential remediation defined in Section 4.2.

Based on the areas of potential remediation identified in Section 4.2 and on the remedial design basis presented in Section 4.3, potentially applicable technologies were identified for the following areas of application:

- ground water recovery
- ground water treatment
- ground water disposal
- soil remediation.

Technologies are divided between ground water and source control (soils). The only compounds in ground water exceeding ARARs are volatile organics. Ground water extraction, treatment and disposal technologies are presented in Table 5.1

Potential risks to human health under baseline conditions posed by site surficial soils are within the acceptable exposure levels defined by the NCP. The only compounds in subsurface soils that could exceed ground water ARARs through leaching are volatile organics. Soil treatment technologies are presented in Table 5.2 according to their method of application (e.g., containment, in situ, etc.).

Site ground water exceeds some ARARs but presents no risks to human health under current conditions. Remediation of soils at the Site is not required based on protection of human health and the environment or for compliance with soils ARARs. The absence of significant risks posed by the Site indicates that extreme remedial efforts are not warranted and that the evaluation of remedial technologies can be limited to those that have demonstrated capabilities and are commercially available.

5.3 GROUND WATER CONTROL SCREENING

Ground water control refers to all elements of potential ground water remediation, including recovery, treatment and discharge. Comprehensive ground water control alternatives will include retained technologies of each element.

4 9 0 1 0 0

TABLE 5.1

POTENTIAL GROUND WATER REMEDIATION TECHNOLOGIES

Recovery

Extraction Wells
Subsurface Drain and Interception Trenches
Alternative Concentration Limits
No Action (Natural Attenuation)

Treatment

Air Stripping
Granular Activated Carbon
Chemical Oxidation (UV-Ozone)
Biological Treatment
Land Treatment

Discharge

Surface Water Discharge
Gaffney Publicly Owned Treatment Works
Horizontal Irrigation
Injection Wells

4 9 0 ; 0 1

TABLE 5.2

POTENTIAL SOIL REMEDIATION TECHNOLOGIES

Direct Treatment

No feasible options for subsurface soils due to excavation restrictions (see text)

In Situ

Soil Vapor Extraction
Enhanced Biodegradation
Soil Flushing
Vitrification

Off-Site Treatment of Disposal

No feasible options for subsurface soils due to excavation restrictions (see text)

Containment

Capping
Slurry Walls
Grouting
Sheet Piling
Bottom Sealing

No Action

Passive Remediation

5.3.1 Ground Water Recovery

The following technologies have been evaluated as a means of recovering contaminated ground water for the purpose of treatment. These technologies will be coupled with the treatment technologies in Section 5.3.2 and discharge technologies in Section 5.3.3 in the development of overall alternatives.

1) Extraction Wells

Extraction wells (or recovery wells) withdraw ground water from distinct points. Multiple extraction wells are placed such that the pumping influence from each individual well overlaps the influence from adjacent wells, thereby providing a concerted withdrawal of ground water containing site-related chemicals.

Aquifer conditions at the Medley Site make the use of extraction wells feasible. Due to the low saturated thickness of the saprolite at the Site, extraction wells will have to be completed into the upper portion of the bedrock (the transition zone) to be effective. Wells screened in this transition zone would influence ground water in both the saprolite and the bedrock. It is anticipated that, due to the water table conditions and hydraulic characteristics of the bedrock/saprolite system at the Site, the well yields and zones of influence will vary between individual installations across the Site. Screened intervals and pumping rates for the extraction wells would be verified through an evaluation of aquifer response conduced during construction of the extraction system. Extraction wells will be retained for further analysis.

Modeling of ground water extraction is summarized in Section 4.3.1 and presented in Appendix B. Figure 4.1 illustrates the two possible extraction system scenarios. Option 1 involves recovery of all ground water at the Site estimated to contain site-related constituents at concentrations currently above MCLs. Option 2 involves extraction of ground water that could cause MCLs to be exceeded at the property boundary in the future. Ground water currently estimated to be above MCLs, but which would be attenuated (through adsorption, dispersion, and degradation) to concentrations below MCLs by the time it reaches the property boundary, would not be extracted. The projected maximum extraction rate for Option 1 would be 30 gpm and for Option 2 would be 15 gpm.

2) Interceptor Trenches and Subsurface Drains

Trenches and drains can be used to collect ground water containing site-related chemicals along a line located hydraulically downgradient from the source. Trenches and drains, in terms of hydraulics, behave similarly to a series of extraction wells installed along a straight line, but extend over a more continuous zone than extraction wells. Drains are generally passive systems, designed to allow ground water to flow into the drain under the natural hydraulic gradient. Interceptor trenches can also be actively pumped to induce flow into the trench.

Subsurface drains and interceptor trenches are more cost-effective than extraction wells at shallow depths. However, at depths greater than about 40 feet, increasing excavation and construction costs reduce their cost-effectiveness.

Depth to ground water at the Site immediately beneath the source area is on the order of 65 feet. Downgradient of the source area, the depth to ground water may be as shallow as 10 feet in limited locations close to the tributary to Jones Creek, but is on the order of 50 feet across much of the Site downgradient from the source area. Therefore, only limited portions of the ground water remediation area may be suitable for application of trenches or drains. Additionally, excavation into bedrock would be required for installation of trenches or drains for recovery of Site ground water exceeding ARARs. Excavation into heterogeneous rock formations at depths of 65 feet and greater along a distance of several hundred feet would be extremely difficult. Placement of the impermeable liner, geotextile filter fabric, collection pipe, and sumps would represent further complications. Thorough collection of Site ground water across the distributed trench line would be questionable. Interceptor trenches are not retained for further evaluation based on implementation concerns.

3) Alternate Concentration Limits

Alternative concentration limits (ACLs) are described in SARA Section 131(d)(2)(B)(ii) and provide for site-specific ground water remediation levels where:

- there are known and projected points of entry of such ground water into surface water; and
- on the basis of measurements or projections, there is or will be no statistically significant increase of such constituents from such ground water in such surface water at the point of entry or at any point where there is reason to believe accumulation of constituents may occur downstream; and
- the remedial action includes enforceable measures that will preclude human exposure to the contaminated ground water at any point between the site boundary and all known and projected points of entry of such ground water into surface water.

Site hydrogeological properties were assessed in Section 4.1.3.1 and are not consistent with the requirements for ACLs. ACLs will not be retained for further evaluation based on effectiveness considerations.

4) No Action

The NCP requires that the no action alternative be retained throughout the Feasibility Study as a basis of comparison during the detailed analysis of alternatives. The no action alternative would leave chemical residuals in ground water and rely on natural attenuation mechanisms to bring concentrations within remediation levels. Ground water downgradient of the Site is not currently used and future uses appear limited considering the existing public water system.

5.3.2 Ground Water Treatment

Compounds exceeding potential ground water remediation levels at the Site are limited to VOCs and the assessment of treatment technologies can be limited accordingly The required level of treatment of extracted ground water will be a function of the selected discharge option.

1) Air Stripping

Air stripping is a mass transfer process in which volatile compounds in ground water are transferred to an air stream, typically within a packed tower. In general, compounds with dimensionless Henry's Law Constants (Hc) greater than 0.01 are readily stripped. As shown in Table 4.8, all of the ground water contaminants should be easily removed through air stripping. EPA considers air stripping to be the best demonstrated available technology for the removal of VOCs from ground water. Air stripping is a proven technology that is effective for Site VOCs and it will be retained for further evaluation.

Maximum VOC emission rates would be based on 100 percent removal of the influent volatile organics. Since air strippers can remove Site volatile organics to below quantitation levels (EPA Method 8010), 100 percent removal is a reasonable assumption. South Carolina considers the following Site VOCs to be air toxics and therefore subject to permitting and/or emissions control:

- 1,2-dichloroethane
- trichloroethene
- tetrachlorethene
- methylene chloride
- chloroform.

The maximum Site emission rate for these compounds would be approximately 44 pounds per month, per the mass loadings in Table 4.6. South Carolina Air Pollution Control

Regulation No. 62.1, Section II, F.2.g states that VOC sources of less than 1000 pounds per month may not require permits but that source information must be supplied to the Department. SCDHEC policy is that any source of air toxics must be reviewed for potential impact to receptors. To satisfy South Carolina requirements, calculated airborne concentrations at the stack were compared with allowable State ambient concentration levels (Air Pollution Control Regulation No. 62.5, Standard No. 8, Toxic Air Pollutants). Chemicals with stack concentrations exceeding State levels were subjected to a conservative air modeling assessment (Appendix G).

The only compound potentially exceeding State acceptable ambient limits at the stack would be 1,2-dichloroethane. Air dispersion modeling to the property line found that airborne concentrations for 1,2-dichloroethane would be below allowable State levels by a factor of more than 1000. Maximum air stripper emissions from the Medley Farm Site would therefore be protective of human health and would not require control. Further consideration of an air stripper for ground water treatment will be based on no emission control requirements.

2) Activated Carbon Adsorption

Activated carbon adsorption is a demonstrated technology for the removal of a large variety c rganic compounds from ground water. The VOCs present in the ground water have organic carbon partitioning coefficients (Table 4.8) that indicate they will be removed by granular activated carbon (GAC) adsorption. A potential disadvantage of GAC adsorption is that organic species other than the compounds of interest will be adsorbed and increase carbon usage. The potential for non-specific adsorption use is a function of the total organic carbon (TOC) of the ground water. The low natural carbon content of saprolite in the Site area suggests that carbon use would not be excessive. Carbon adsorption is a proven technology for ground water remediation and will be retained for further evaluation.

3) Chemical Oxidation

In chemical oxidation, the oxidation state of the treated compound is raised through chemical addition. Organic compounds can ultimately be oxidized to carbon dioxide and water, although such extensive treatment is generally not necessary. The most powerful form of oxidation and the method of choice for ground water treatment is ultra-violet (UV) catalyzed ozonation. Ozonation has been applied successfully for the treatment of VOCs at a number of ground water remediations. Chemical oxidation will be retained for further analysis.

4) Biological Treatment

As shown in Table 4.8, the majority of compounds are not amenable to aerobic biodegradation. The majority of compounds are potentially amenable to anaerobic biodegradation but there is the possibility of forming terminal end products, such as vinyl chloride, that would require further treatment. Anaerobic reactors are also more difficult to control than aerobic systems, especially at the low anticipated ground water concentrations. For reasons of effectiveness and implementability, biological treatment will not be retained for further evaluation.

5) Land Treatment

nd treatment involves applying ground water to the soil and optimizing degradation through the addition of nutrients and oxygen. Removal of VOCs occurs through biodegradation and volatilization. As discussed under Biological Treatment, VOCs at the Site are not amenable to aerobic biodegradation. Climatic conditions in the Piedmont of South Carolina are not conducive to year round volatilization of VOCs through land application. For effectiveness reasons, land treatment is not feasible and will not be retained.

5.3.3 Ground-Water Discharge

Ground water must be discharged after recovery and treatment. The level of ground water treatment required is a function of the selected discharge option. Potential methods for the discharge of treated ground water are listed below.

1) Surface Water Discharge

Surface water discharge may include the discharge of treated ground water into a stream, river, or a storm sewer. Site ground water would be discharged to Jones Creek. Surface water discharge would not require a National Pollutant Discharge Elimination System (NPDES) permit, since Jones Creek can be accessed within the Medley property and on-site CERCLA actions do not require permits (SARA Section 121(e)). Any discharge would have to conform to the substantive requirements of an NPDES permit as administered by the State of South Carolina.

Allowable levels for discharge to Jones Creek would be based on blended concentrations in the surface water. Base flow from Jones Creek at the Site is the 7Q10 value of 200 gallons per minute (Section 4.1.2.). Instream concentrations based on direct discharge of the maximum ground water concentrations (Table 4.6) at the maximum extracted flow rate of 30 gpm are compared with Federal Ambient Water Quality Criteria (AWQC) in Table 7 1 Even without treatment, the maximum chemical loadings to Jones Creek would satisfy Federal AWQC and be protective of aquatic life. All of the retained treatment technologies are capable of achieving a reduction in VOC levels that would provide a level of safety and satisfy discharge requirements. Surface water discharge is technically feasible and will be retained for further evaluation.

2) Publicly Owned Treatment Works (POTW)

Municipal sewer service ends at the Gaffney city limits, a distance of approximately four miles from the Site. There are no plans to expand sewer service towards the Site in the near future. Construction of a force main and lift stations the required distance would create utility, traffic and aesthetic concerns along the service length during construction. This option would require considerably more time to implement and would be considerably more costly than the other discharge options. Discharge to a POTW is therefore not feasible based on implementability and cost considerations and will not be retained for further evaluation.

3) Horizontal Infiltration Gallery

With horizontal infiltration, the treated ground water is pumped into trenches lined with gravel and allowed to percolate into the soil. A positive hydraulic head is the driving force behind the system, as opposed to an active pumping system injecting the water into the subsurface. The success of this method is dependent on vadose zone acceptance of the treated water and an approved method of percolation testing would be required to determine permissible application rates of treated water. The infiltration gallery must be located so that recharge to the aquifer does not interfere with the performance of the extraction system.

Specific regulations governing the operation of infiltration galleries have not been promulgated. However, SCDHEC might interpret the South Carolina Water Classifications and Standards (Regulations 61-68) as applicable to water allowed to infiltrate to ground water at the Site. The aquifer has been classified by EPA as a Class IIA aquifer. This classification is equivalent to the South Carolina Class GB. Based on this equivalency, it is anticipated that water discharged to the infiltration galleries would be required to meet EPA primary drinking water standards (MCLs) for the volatile organic compounds detected in the ground water.

Site soils have an estimated permeability of 0.5 gpd/ft^2. Based on a maximum extraction system flow rate of 30 gallons per minute, infiltration galleries could be technically and economically effective. The feasibility of this technology is dependent on the refined extraction rate, the allowable application rate for Site soils and suitable application areas.

Any infiltration galleries would have to be located downgradient of the extraction system to avoid interfering with the ground water capture zones. A significant portion of any such water would eventually discharge into Jones Creek. Infiltration galleries will be retained provisionally pending a final determination of the allowable application rates.

4) Injection Wells

Ground water pumped from the extraction system could be discharged via corrective action injection wells on the Medley property. South Carolina Underground Injection Control (UIC) Regulations (Title 48, Chapter 1, amended March 23, 1990) include a provision for corrective action wells used to inject ground water associated with aquifer remediation (R61-87.11.E), specified as Class V.A.i wells.

A State permit would not be required for UIC wells since this would be an on-site CERCLA action but their design and operation would have to conform to SCDHEC requirements. The UIC regulations require that monitoring wells be installed to monitor any underground sources of drinking water which could be affected by the injection operation. The number, location, construction and frequency of monitoring would be established in the permit based on criteria such as proximity of the injection operation to points of withdrawal of drinking water, and the injection well density. At a minimum, requirements would include monitoring the nature of injected fluids, flow rates, and demonstration of mechanical integrity. Monitoring wells are required to be monitored semi-monthly, with quarterly reports submitted to the Department of Health and Environmental Control. Discharge concentrations would be subject to State review but are anticipated to be set at MCLs.

A potential difficulty associated with implementation of injection wells at the Site is the identification of water-bearing features that could accept the total treated flow. Saprolite and deep bedrock at the Site have limited hydraulic conductivity and are not likely discharge zones. The transition zone is the most likely formation for injection of treated ground water. Injection into the transition zone would have to be downgradient of the extraction system so as not to interfere with the ground water capture zones. The transition zone downgradient of the potential extraction systems is anticipated to be highly variable and might not accommodate the required discharge rates. In addition, a significant portion of any ground water injected downgradient of the potential extraction systems would be expected to discharge to Jones Creek after a short distance in the subsurface. Underground injection might therefore offer no significant advantages over direct discharge to Jones Creek.

Discharge of extracted ground water at the Medley Site could potentially be accomplished through the use of injection wells pending verification of injection acceptability. The number of wells, locations, injection rates, and operating details would be established in conjunction with the final design of the extraction system. This technology will be retained provisionally for further analysis based on the availability of acceptable injection zones.

5.4 SOURCE CONTROL SCREENING

Source control measures address the subsurface soils above calculated remediation levels identified in Section 4.2.2. Potential source control technologies are evaluated within the categories shown in Table 5.2. The purpose of this section is to screen the potential source control technologies under the criteria presented in Section 5.1. Only the technologies retained after this screening will be used to develop remedial action alternatives.

5.4.1 Direct Treatment

The term direct treatment, as used here, refers to the excavation of unsaturated soils followed by on-site treatment. Potential on-site technologies include:

- biological treatment (bioreactor, land farming)
- chemical extraction
- chemical oxidation
- soil washing

- stabilization
- low-temperature thermal desorption
- transportable incineration.

Subsurface soils potentially requiring remediation extend to approximately 65 feet below land surface. This depth exceeds the reach of large hydraulic excavators (backhoes) and a crane-mounted clam shell would be required. The relict rock structure and accompanying consolidation of Site saprolite indicates that excavation by clam shell would be a tedious and equipment-intensive process. Soil borings conducted during the Phase I investigation encountered auger refusal at various depths. VOC concentrations in the deepest soil boring interval collected in the Phase I investigation (25-27') were all less than 1 mg/kg. Subsequent soil intervals would be expected to contain similar concentrations. Extensive excavation of the Site to a depth of 65 feet followed by intensive treatment at the surface for trace levels of VOCs is not warranted when proven in situ methods such as soil vapor extraction (Section 5.4.2) are available. For these reasons, remedial methods for subsurface soils based on excavation will not be considered further.

5.4.2 In Situ Treatment

In situ treatment for soil remediation are performed without excavation, using the soil matrix as the treatment zone. The absence of excavation requirements for in situ treatment is an important consideration because of the consolidated soils and depth of the unsaturated zone at the Site. Potential options include soil vapor extraction, enhanced biodegradation, soil flushing, and vitrification.

1) Soil Vapor Extraction

Soil vapor extraction (SVE) involves the removal of volatile organics from the soil matrix by mechanically drawing or venting air through the unsaturated soil layer. The process typically includes a series of slotted vertical injection vents connected by a common manifold to an extraction pump or blower. Volatile compounds are withdrawn through an induced pressure gradient in the subsurface. Air emissions may require further treatment before they are vented to the atmosphere.

Site conditions are appropriate for the application of SVE. Soil permeability is approximately 10^{-4} cm/s based on hydraulic conductivity testing in saprolite wells (RI Table 4.1). A SITE demonstration showed that SVE systems are effective in soils with permeabilities of 10^{-8} cm/s when the porosity has been sufficient (Stinson, 1989). The grain size analysis described in Section 4.3.3 indicates that porosity at the Site is approximately 30 percent, which would be sufficient for application of SVE. This determination of potential SVE effectiveness is based on air flow parameters (porosity), which govern performance more than liquid flow parameters (permeability).

SVE is effective for compounds with a Henry's Law constant, H_c (dimensionless), of at least 0.001. As shown in Table 4.8, Site compounds have H_c values significantly above this and can be effectively removed through SVE. The calculated soil remediation levels in Table 4.3 can be achieved using SVE.

SVE has the potential for direct and indirect removal of semivolatile organics (SVOCs) as well. Application of SVE at the Bluff Road NPL Site in Columbia, SC achieved direct removal of SVOCs through mass transfer to withdrawn air. Compounds such as 1,2,4,-trichlorobenzene were measured at significant levels in the air steam prior to vapor phase treatment. Generally, SVOC removal at that site followed VOC removal. This effect is consistent with the lower H_c values for SVOCs.

SVOC removal is generally based on H_c value. The following Site SVOCs have the potential for significant removal through SVE:

- 1,4,-dichlorobenzene
- 1,2,4-trichlorobenzene.

A secondary effect of SVE is to stimulate biodegradation through the passage of air and concomitant increase in oxygen levels. The following Site SVOCs are expected to be amenable to aerobic biodegradation (EPA, 1987):

- benzoic acid
- phenol
- phthalates.

South Carolina regulations for the exemption of air emission from an SVE system are the same as for an air stripper (Section 5.3.2). Emissions concentrations are a function of the soil chemical concentrations, the SVE air flow rate, and the soil desorption kinetics and are difficult to estimate. Empirical relationships developed by vendors from field experience are generally the best predictors of volatile organic emissions. The need for off-gas control would be determined during Remedial Design, should this technology be selected for implementation. Control of VOC emissions can be achieved using an activated carbon or catalytic oxidation unit. To provide a conservative cost estimate, an activated carbon emissions control system has been included in the FS. The actual need for off-gas control would be dependent on achieving ambient air standards at the property line.

An SVE system can also be used for localized ground water recovery through the use of dual vapor/water extraction wells. The applied vacuum enhances ground water recovery in soils with limited production, such as at the Site. After reaching equilibrium, the dual extraction system can lower the effective water table through continuous extraction of vapor and ground water. This increases the effectiveness of VOC removal by increasing the volume of unsaturated soils available for vapor extraction. VOCs in unsaturated soils are more quickly removed through SVE than they are in the saturated zone through long-term ground water pumping. If saturated soils can be adequately dewatered, treatment by SVE can significantly shorten the time required for remediation.

SVE recently passed pilot-scale testing at the Bluff Road NPL Site in Columbia, South Carolina for the removal of volatile and semi-volatile organics and was selected as the source control action in the Record of Decision (ROD). The process has also been used successfully for full-scale remediation projects in the Piedmont region (Vicellon facility, Fountain Inn, SC). Because of the review of case studies at sites with similar geology and compounds, SVE appears feasible for application at the Site and is retained for further evaluation.

2) Enhanced Biodegradation

In situ biodegradation involves enhancing the naturally occurring microbial activities found in subsurface soils. The low permeability of the soils at the Site would limit the effective application of nutrients. Compounds with moderate octanol-water partitioning coefficients, such as the chlorinated VOCs present at the Site, are typically non-polar and have low aqueous solubilities. Such properties enhance the compounds sorption onto soils and reduces their availability for biodegradation. Chlorinated compounds are also resistant to aerobic biodegradation, which is more proven than anaerobic biodegradation.

The low permeability of Site subsurface soils and the presence of chlorinated VOCs make bioremediation infeasible for the Site. In situ biodegradation is removed from further consideration because of effectiveness and implementation concerns.

3) Soil Flushing

Soil flushing is a method of extracting chemicals from unexcavated soils using an injection, extraction and recirculation system. Selection of the optimal washing fluid is based on characteristics of the chemicals and of the soil matrix.

General difficulties facing effective implementation of surfactant-assisted soil flushing include the need for intensive soil contact followed by thorough collection of leachate. The low permeability of Site soils would limit the effective application and distribution of washing fluids. The chlorinated VOCs present at the Site generally have moderate octanol-water coefficients, making them difficult to remove from soils. The greatest concern regarding soil flushing is that mobilized compounds would not be completely recovered by the extraction system and therefore could degrade ground water conditions. Washing fluids tend to solubilize chemicals and therefore might hinder subsequent treatment efforts. Soil flushing failed a recent EPA field demonstration test (Hazardous Waste Consultant, 1988a). For effectiveness reasons, soil flushing will be removed from further consideration.

4) Vitrification

In-situ vitrification is a process of melting wastes and soils or sludges in place to bind the waste in a glassy, solid matrix resistent to leaching and more durable than graphite or marble. It was originally developed for treatment of radioactive wastes, although it has potential for use with soils contaminated with heavy metals, inorganics, and organic wastes.

The process consists of placing electrodes in the soil and constructing trenches filled with a flaked graphite and glass fruit mixture to connect the electrodes in an "X" pattern. Voltage is then applied to the electrodes and the graphite/glass fruit mixture is quickly heated to 3600°F, which is well above the melting point of soil (2000 to 2500°F). A molten zone expands horizontally and vertically to encompass the volume between the electrodes. As the soil melts, organic wastes are pyrolized and combust when they come in contact with air. The high temperatures at the surface cause virtually complete combustion of the organics in the gases. Hazardous compounds that do not volatilize remain in the molten soil and become part of the glass and crystalline product after cooling. Non-combusted volatiles are collected in an off-gas hood for treatment. When the desired vitrification depth is reached, the electrodes are turned off and the soils are allowed to cool.

In-situ vitrification tests have been completed on an engineering scale (0.05 - 1.0 tons of soil), a pilot-scale (10 tons of soil) and a large-scale (400 to 800 tons of soil). Bench-scale results for PCB-contaminated soils showed overall destruction and removal efficiencies (DRE's) of >99.99% and tests on soils contaminated with 2,3,7,8-TCDD give similar results (Hazardous Waste Consultant, 1988b). No full-scale experiments have been conducted on soils to the depth as those at the Site. Further testing would be required prior to full-scale application.

Because of the limited experience treating soil depths similar to those at the Site and the availability of proven in situ methods of volatile organics, in-situ vitrification will be removed from further consideration.

5.4.3 Off-Site Treatment or Disposal

Remediation of contaminated soils and residual materials can potentially be handled off-site. To be an acceptable alternative, source control alternatives involving off-site treatment, destruction, or disposal must:

1. be more cost effective than other remedial actions,
2. create new waste management capacity, or be necessary to protect public health and welfare or the environment; and
3. satisfy best demonstrated available technologies (BDAT) requirements.

These specifications are listed in Section 300.70(c) of the National Contingency Plan (NCP). The removal and transportation of contaminated materials involves the potential of increased risk to workers and the surrounding population as compared to equally effective on-site remediation efforts.

The current NCP requires that off-site treatment and disposal methods be considered as potential remedial alternatives. Off-site options would require excavation of Site soils, however, and therefore be under the same restrictions described for direct treatment options (Section 5.4.1). Effective on-site options (in situ, containment) exist for Site soils. Because of technical difficulties and the availability of proven on-site options, off-site options will not be considered further.

5.4.4 Containment

Containment alternatives minimize leaching of chemicals from the soil by providing low permeability barriers to infiltration, thereby preventing chemical transport to the ground water. Containment can be used to isolate and reduce mobility of large waste disposal areas where other technologies would be technically or economically infeasible. Containment strategies have been applied successfully at numerous hazardous waste sites.

1) Capping

Capping is a process used to cover buried waste materials to prevent their contact with the land surface and ground water. A cover is often employed as a remedial measure at a site in conjunction with other remedial technologies such as drainage and revegetation. Should Construction of a standard RCRA cap or an alternative cap meeting the intent of the RCRA regulations is achievable at the Site.

Capping offers proven protection against vertical leaching of chemicals through precipitation to the ground water. Operational considerations include the need for long-term maintenance and an uncertain design life. Present worth maintenance costs are typically less than excavation and treatment, however, and experience over the last few years at hazardous waste sties has allowed better estimation of cover longevity. Synthetic liners supported by a low permeability base may last over 100 years (EPA, 1985)

Capping is most effective when the chemicals present are not highly mobile. The octanol-water coefficients indicate a moderate mobility for Site compounds, making the Site appropriate for capping. Further leachability of these compounds is expected to be minor and can be reduced by placement of the cap and additional surface controls. Capping will also reduce any potential for uncontrolled exposure to the waste residuals remaining at the Site. Capping is therefore retained for further evaluation.

2) Slurry Walls

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Slurry walls are the most common subsurface barriers at hazardous waste sites because they can vastly reduce ground water flow in unconsolidated earth and are readily constructed. In addition, they provide a means of establishing an inward hydraulic gradient when combined with ground water extraction systems, further reducing contaminant mobility. Slurry walls are almost always used in conjunction with other means of containment or treatment. Generally, they are constructed in vertical trenches that are excavated under a slurry. For a typical soil-bentonite installation, the slurry hydraulically shores the trench walls to prevent collapse while forming a filter cake on the trench walls to minimize fluid losses into the surrounding soils. An appropriate backfill is added to complete the installation. Alternate installation methods are also available that could be considered for this technology.

Design parameters for slurry walls include vertical depth and horizontal placement. Walls that extend into a low permeability zone are called keyed and those that extend partially into the water table are called hanging. Hanging walls are used to control free product which floats on top of the ground water. Since chemicals at the Site are within their solubility limits, keyed slurry walls are the only type requiring further consideration.

The effective use of slurry walls requires a uniform low permeability zone for the bottom of the slurry wall to be firmly connected. The resulting seal forms a low permeability barrier to ground water flow. Site geology in the saturated zone consists of saprolite underlain by fractured bedrock. A slurry wall could not be adequately keyed into the bedrock and the underlying fracture system would not allow formation of a hydrologic barrier. Slurry walls could not be implemented as designed at the Site and would have limited effectiveness. For these reasons, slurry walls will not be considered further.

3) Other Options

Other containment options for control of ground water migration include:

Grouting involves the injection of fluids that become impermeable upon setting into minor rock formations to form a hydrologic seal. The transition zone and fractures at the Site are too extensive for effective grouting and this technology will not be retained.

Sheet piling involves the placement of interlocking steel sections into the subsurface to form a low permeability barrier. The depth to ground water exceeds the limit of sheet pile construction and the fractured bedrock would not allow a low permeability connection. Sheet piles will not be considered further.

Bottom sealing involves the injection or insertion of an inert impermeable and continuous horizontal barrier in soil beneath the source of disposal. Pilot-scale testing conducted by the United States Army Corps of Engineers (USACE) Waterways Experiment Station (EPA, 1986) determined that the current state of chemical grouts and their method of application is poorly suited for bottom sealing. This technology will not be considered further.

5.4.5 No Action

No action at the Medley Farm Site is more accurately referred to as no further action, since the great majority of chemical residuals were removed during the immediate removal action. The National Oil and Hazardous Substances Contingency Plan (NCP) directs that the no action alternative be retained during the Feasibility Study. The no action alternative references the Site risk assessments and presents a baseline of performance with which to evaluate other alternatives. Site soils would be left in place under this alternative and ground water migration would be mitigated solely through natural attenuation. While this alternative involves no active remediation, limited site control may be exercised to deter future access. Typical options could include construction of a perimeter security fence and deed restrictions.

5.5 TECHNOLOGY SCREENING SUMMARY

Potential technologies were screened according to the technical criteria in Section 5.1. Summaries of the evaluations for migration and source control are presented below

5.5.1 Ground Water Control

The screening of ground water control technologies is presented separately below for ground water recovery, treatment and discharge. A summary of the technical evaluations is presented in Table 5.3.

5.5.1.1 Ground-water Recovery

Two technologies and a control strategy were evaluated for the extraction of Site ground water. Extraction wells were retained due to their proven effectiveness while an interception trench was rejected because of implementation difficulties and limited effectiveness. Site conditions are not appropriate for the application of ACLs. The no action alternative was retained as required by the NCP to provide a baseline of comparison.

5.5.1.2 Ground-water Treatment

The only compounds in ground water exceeding ARARs are VOCs and the evaluation of potential treatment technologies was limited accordingly. A total of five technologies were evaluated and three were retained. Air stripping, carbon adsorption, and a UV-catalyzed ozonation were retained because of their demonstrated effectiveness towards VOCs

Biological treatment and land treatment were rejected because chlorinated VOCs are resistant to biodegradation.

TABLE 5.3
GROUND WATER CONTROL
TECHNOLOGY SUMMARY

TECHNOLOGY	STATUS	REASON
GROUNDWATER RECOVERY		
EXTRACTION WELLS	RETAINED	
SUBSURFACE DRAINS/ INTERCEPTION TRENCHES	REJECTED	CANNOT BE INSTALLED AT DEPTH IN BEDROCK
ACLs	REJECTED	SITE CONDITIONS NOT APPROPRIATE
NO ACTION	RETAINED	
GROUNDWATER TREATMENT		
ACTIVATED CARBON ADSORPTION	RETAINED	
CHEMICAL OXIDATION	RETAINED	
BIOLOGICAL SYSTEM	REJECTED	CHLORINATED VOCS RESISTANT TO BIODEGRADATION
AIR STRIPPING	RETAINED	
LAND APPLICATION	REJECTED	RESISTANT COMPOUNDS, SEASONAL USE
GROUNDWATER DISCHARGE		
SURFACE WATER (JONES CREEK)	RETAINED	
GAFFNEY POTW	REJECTED	DISTANCE TO SERVICE
INFILTRATION GALLERY	RETAINED	PROVISIONALLY DEPENDING ON APPLICATION RATES
INJECTION WELL	RETAINED	PROVISIONALLY DEPENDING ON APPLICATION RATES

5.5.1.3 Ground-water Discharge

Four options were evaluated for the discharge of treated ground water. Discharge to a surface water (Jones Creek) and injection wells were retained as being technically effective and allowed under State law. Horizontal infiltration galleries were provisionally retained for ground water recovery Option 2. Discharge to the sewer system was not retained because of the distance to the nearest connection (approximately four miles).

5.5.2 Source Control

Technologies were evaluated under the categories of:

- direct treatment
- off-site treatment or disposal
- in situ treatment
- containment
- no action.

Excavation of subsurface soils at the Site was considered infeasible because of the depth to the water table, the consolidated nature of the saprolite, the low (1 mg/kg) levels of VOCs in the deep soils, and the availability of demonstrated technologies that did not require excavation. Accordingly, technologies involving direct treatment or off-site treatment or disposal were not considered further for subsurface soils.

Four in situ technologies were evaluated. Soil vapor extraction was retained because of its demonstrated effectiveness towards VOCs and its applicability to Site conditions. Enhanced biodegradation was rejected because of its limited effectiveness towards chlorinated VOCs and the depth and low permeability of Site soils. Soil flushing was rejected because of poor pilot-testing performance and the limited permeability of the unsaturated zone. Vitrification is not sufficiently demonstrated for use at Site depths.

Capping was the only retained containment technology. Subsurface containment methods, such as slurry walls, would be ineffective because of the fractured bedrock and were not retained for further evaluation.

A summary of the source control technology screening is presented in Table 5.4.

TABLE 5.4
SOURCE CONTROL
TECHNOLOGY SUMMARY

	TECHNOLOGY	STATUS	REASON
DIRECT TREATMENT	BIOREACTOR	REJECTED	EXCAVATION OF SITE TO REQUIRED
	LAND TREATMENT	REJECTED	DEPTH IS CONSIDERED INFEASIBLE
	SOIL WASHING	REJECTED	
	CEMENT-BASED STABILIZATION	REJECTED	
	SILICATE-BASED STABILIZATION	REJECTED	
	PROPRIETARY CHEMICAL FIXATION	REJECTED	
	LOW-TEMPERATURE DESORPTION	REJECTED	
	ROTARY KILNS	REJECTED	
	INFRARED THERMAL TREATMENT	REJECTED	
	FLUIDIZED BED INCINERATION	REJECTED	
IN-SITU TREATMENT	ENHANCED BIODEGREDATION	REJECTED	PERMEABILITY, DEPTH OF SOILS
	SOIL FLUSHING	REJECTED	FAILED EPA FIELD TEST, SOIL PERMEABILITY
	SOIL VAPOR EXTRACTION	RETAINED	
	VITRIFICATION	REJECTED	NOT SUFFICIENTLY DEMONSTRATED
OFF-SITE TMT/DISP	COMMERCIAL LANDFILLING	REJECTED	EXCAVATION OF SITE TO REQUIRED
	COMMERCIAL INCINERATION	REJECTED	DEPTH IS CONSIDERED INFEASIBLE
CONTAINMENT	CAPPING	RETAINED	
	SLURRY WALLS	REJECTED	FRACTURED BEDROCK PREVENTS EFFECTIVE USE
	GROUTING	REJECTED	CANNOT BE EFFECTIVELY APPLIED
	SHEET PILING	REJECTED	NOT APPLICABLE TO ROCKY SOILS, DEPTHS
	BOTTOM SEALING	REJECTED	NOT FULLY DEVELOPED
NO ACTION		RETAINED	

6.0 DEVELOPMENT OF ALTERNATIVES

Remedial action alternatives represent a directed application of feasible technologies towards areas of potential risk. The technology screening in Section 5 evaluated options on an individual basis without reference to their part in a comprehensive remedial action. The purpose of this section is to assemble the retained technologies into functional alternatives considering site-specific factors and then to evaluate the alternatives collectively. This initial screening of alternatives has been utilized to select the best remedial schemes based on the overall nature of the Site. The alternatives retained from this evaluation are subjected to a detailed analysis in Section 7.

As was done for the technology screening, potential alternatives are developed for ground water control and source control. A comprehensive Site remedial action would involve an alternative from each area. The NCP requires that a range of alternatives which employ treatment to reduce the toxicity, mobility, or volume of contaminants be developed. This range includes at least one alternative which removes or destroys the residual chemicals, and to the maximum extent feasible eliminates or minimizes the need for long-term management. Alternatives have also been developed which involve little or no treatment but which provide protection of human health and the environment by preventing or controlling exposure to the contaminants through engineering controls or institutional controls. The no action alternative has also been retained for each media.

6.1 AREAS OF POTENTIAL REMEDIATION

Determination of those areas potentially meriting remediation was performed through the baseline risk assessments (Section 3) and through the assessment of chemical-specific ARARs (Section 4). Existing significant risks and the capability to generate future impacts on other media are both criteria for targeting areas for potential remediation. The Site poses no existing significant risks, but does present the possibility of generating future impacts. Based on the latter criteria, areas of potential remediation are described individually below. The given volumes and areas of media are summarized from calculations described in Section 4.3.

6.1.1 Ground Water Control

Ground water currently poses no risks to human health and the environment, although the baseline risk assessment determined that future uses of the ground water on the Site present unacceptable risks to human health if the ground water were used for potable purposes. The existing public water supply makes this possibility unlikely. However, because Site ground water exceeds Federal and State levels (MCLs), potential remedial alternatives will include two extraction options:

- extraction and treatment of all Site ground water currently exceeding MCLs (Option 1)
- extraction and treatment of all Site ground water such that all future ground water at the property line would achieve MCLs (Option 2)

Both extraction options would eliminate the potential for human health risks in the future

6.1.2 Source Control

Site soils present no significant risks to human health or the environment. The only Federal or State standards for soils are the TSCA levels for PCBs. Site soils are below the TSCA level for unrestricted access. Remediation of Site soils is therefore not required under compliance with ARARs considerations. Potential remediation is indicated for those soils with residual concentrations that could impact ground water above MCLs. VOCs are the only compounds with the potential to cause Site ground water to exceed MCLs, as determined in Section 4.1.3.2. Site soils exceeding calculated remediation levels are limited to three areas corresponding to former lagoons and drum disposal depicted in Figure 4.5.

Remedial alternatives will be developed that specifically address these areas. Residual chemical concentrations at other locations at the Site are below calculated levels that could result in exceeding ground water standards.

The NCP requires that a range of alternatives be developed for source control actions. The most conservative estimate of potential remedial requirements would be based on all soils that exceed quantitation limits at the Site. While not indicated by risks to human health and the environment or exceedance of ARARs, remedial alternatives will be developed that address the entire extent of site-related chemicals in soils.

6.2 GENERAL SCREENING CRITERIA

The purpose of this section is to screen defined alternatives through a comparative evaluation and generate a refined list for detailed analysis. Screening is conducted under the broad criteria of effectiveness, implementability and cost. Descriptions of these criteria are presented below. Within these criteria, consideration is given to construction and implementation activities (short-term effectiveness) and any residual risk remaining after the completion of remedial activities (long-term effectiveness). While the screening at this stage is general, pending the more thorough and extensive analysis in Section 7, the evaluation is sufficiently developed to allow differentiation among alternatives.

6.2.1 Effectiveness

The primary consideration for an alternative is its protectiveness of human health and the environment. Associated considerations include the reduction in toxicity, mobility or volume of Site residuals that will be achieved. Short-term factors include protection of the community and on-site workers during construction and implementation. Long-term factors include potential risks from remaining residuals and the potential need to replace the remedy in the future.

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6.2.2. Implementability

The implementability criterion evaluates the technical and administrative feasibility of constructing, operating, and maintaining an alternative. Technical feasibility refers to the ability to construct, reliably operate, and satisfy action-specific regulations. Administrative considerations include the ability to obtain regulatory approvals (where necessary), public acceptance, available treatment/disposal capacity, and the availability of necessary equipment and personnel.

6.2.3 Cost

Cost is a secondary criteria used to evaluate equivalent alternatives. Those alternatives that are equivalent in cost but clearly would not achieve as effective a remediation as other alternatives are rejected from further consideration. Alternatives that achieve the same level of treatment but at considerably higher cost also are rejected. Otherwise, cost is not used as an elimination criteria at this juncture.

General capital, mobilization, start-up, and operational costs are considered during the evaluation of technologies. Because of the limited detailed technical information available and the accuracy required for this phase of the evaluation, only a preliminary cost analysis is necessary. Present worth costs are used to allow common comparison of alternatives.

6.3 FORMULATION OF POTENTIAL ALTERNATIVES

Potential remedial alternatives are presented separately below for source control and ground water control. The alternatives developed for each area should include each of the following categories:

- No action. As a subset of this category, a limited action alternative may be proposed. Limited action could include monitoring and institutional restrictions but no actual treatment or control of site materials;

- containment and/or control options with little or no treatment;
- alternatives including, as a principal element, treatment which significantly reduces the toxicity, mobility, or volume of chemical residuals;
- alternatives involving permanent remedies and requiring no long-term management of residuals.

6.3.1 Ground Water Control

Ground water control alternatives involving direct remediation would include elements of ground water recovery, treatment and discharge. These elements would be required for both extraction options (1 - current MCLs and 2 - MCLs at the property line) These elements are evaluated individually below. The no action alternative is developed under the ground water recovery alternatives.

6.3.1.1 Ground-water Recovery

The only retained technology for ground water recovery is extraction wells. All ground water remediation alternatives will be based on the use of extraction wells. The no action alternative will be developed for ground water control, as required by the NCP.

6.3.1.2 Ground-water Treatment

Ground water treatment is directed at the removal of volatile organics. Retained technologies are air stripping, carbon adsorption, and chemical oxidation. All of these technologies can be designed to handle the anticipated flow rates and mass loadings. The required level of treatment is dependent on the selected discharge option, although all of the retained options can meet the range of anticipated effluent concentrations.

6.3.1.3 Ground-water Discharge

The retained ground water discharge options are to a surface water (Jones Creek), infiltration gallery or an injection well. Discharge to a surface water would be based on Ambient Water Quality Criteria while discharge to an infiltration gallery or injection well would be governed by MCLs. CERCLA actions taking place entirely on site are exempt from obtaining permits but must comply with the substantive aspects of the relevant permit.

6.3.1.4 Concerted Ground Water Alternatives

Potential technologies for each element of ground water remediation have been combined in a logical, technically sound fashion to create overall alternatives for ground water control. Each of the comprehensive alternatives for ground water control are described below and summarized in Table 6.1.

ALTERNATIVE GWC-1: No Action

This alternative is required under the NCP. There would be no ground water extraction under this alternative and hence no treatment or discharge. Mitigation of chemical migration would be through natural attenuation processes such as adsorption and dispersion. Alternative GWC-1A would be a true no action alternative and involve no further activities to assess ground water migration potential. This alternative is supported by the projected absence of any receptors for Site groundwater and by modeling that indicates average ground-water concentrations at the property line over a 70 year period would be below MCLs (Table 4.7). Alternative GWC-1B would include long-term monitoring of Site ground water for VOCs and deed restrictions.

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TABLE 6.1

POTENTIAL REMEDIAL ALTERNATIVES
MEDLEY FARM SITE

Alternative	Description
	GROUND WATER CONTROL
GWC-1	No action
A	No additional activities
B	Institute long-term ground water monitoring
GWC-2	Recovery of all ground water above MCLs
A	Treatment using air stripping
B	Treatment using carbon adsorption
C	Treatment using chemical oxidation
GWC-3	Recovery of all ground water that could exceed MCLs at the property line
A	Treatment using air stripping
B	Treatment using carbon adsorption
C	Treatment using chemical oxidation
	SOURCE CONTROL
SC-1	No action
SC-2	Capping of source areas
SC-3	Soil vapor extraction in areas exceeding calculated soil remediation levels

Alternative GWC-1A: No further activities

Alternative GWC-1B: Long-term monitoring of Site ground water

ALTERNATIVE GWC-2: Recovery and treatment of all site ground water currently exceeding MCLs

All Site ground water currently exceeding MCLs, would be recovered using extraction wells, treated and discharged on site. The maximum anticipated ground water extraction rate is approximately 30 gpm. The estimated extraction system layout is presented in Figure 4.1. Treatment options include air stripping, carbon adsorption and chemical oxidation.

Discharge options for treated ground water are to a surface water (Jones Creek) or provisionally to an infiltration gallery or an injection well system. Discharge to the infiltration gallery or the injection well system were provisionally retained because their feasibility cannot be determined until field testing is conducted to establish that the required flow rates can be discharged at the Site. Infiltration or injection would be conducted downgradient of the extraction system and a significant portion of water would eventually discharge to Jones Creek, limiting any advantages of these systems over direct discharge. Both infiltration and injection would be considerably more costly and more difficult to operate and maintain than direct discharge to Jones Creek (although accurate costs cannot be estimated prior to field testing). Discharge of Site ground water to Jones Creek would be protective of aquatic life even without treatment. Treated ground water from the immediate removal action was successfully discharged to Jones Creek. Because of the demonstrated acceptability of discharge to Jones Creek and implementation questions regarding infiltration and injection, the most feasible option for discharge of treated ground water is to Jones Creek. For purposes of the FS, ground-water discharge will be to Jones Creek. The actual discharge point would be determined during Remedial Design.

Alternative GWC-2A:	Extraction of ground water above MCLs, air stripping, discharge to surface water.
Alternative GWC-2B:	Extraction of ground water above MCLs, carbon adsorption, discharge to surface water.
Alternative GWC-2C:	Extraction of ground water above MCLs, chemical oxidation, discharge to surface water.

ALTERNATIVE GWC-3: Extraction and treatment of all ground water that could exceed MCLs at the property line.

Site ground water that could potentially exceed MCLs at the property line in the future would be extracted, treated and discharged on site. The baseline risk assessment determined that future ground water concentrations would pose potentially significant risks to human health should a potable well be constructed at the property line. MCLs are Federal and State drinking water levels and therefore this alternative would be protective of human health. The estimated ground water extraction rate for this alternative would be approximately 15 gpm. Treatment and discharge options are as described under Alternative GWC-2.

Alternative GWC-3A:	Extraction of ground water that could exceed MCLs at property line, air stripping, discharge to surface water.
Alternative GWC-3B:	Extraction of ground water that could exceed MCLs at property line, carbon adsorption, discharge to surface water.
Alternative GWC-3C:	Extraction of ground water that could exceed MCLs at property line, chemical oxidation, discharge to surface water.

6.3.2 Source Control

Source control addresses residual chemicals remaining in the unsaturated soils. As described in Section 6.1, soils exceeding the calculated levels protective of ground water (RA-1, RA-2, and RA-3 in Figure 4.2) will be considered for potential remediation. The no action alternative would be developed as a baseline of comparison for remedial alternatives Source control alternatives are described below and summarized in Table 6.1.

ALTERNATIVE SC-1: No Action

Soils would be left in place and no remedial efforts would be conducted under this alternative. Site soils present no significant risks to human health and there are no ARARs governing allowable chemical levels. Security measures (e.g. fencing) or deed restrictions are therefore not required. Soils would continue to act as a source of chemicals to ground water under this alternative. This alternative is required under the NCP.

ALTERNATIVE SC-2: Capping of source areas

Source areas would be covered with a low permeability cap under this alternative. Capping would greatly restrict infiltration to site soils and thereby remove the driving force for chemical migration to the ground water. While capping would also isolate surficial soils from potential human exposure, this measure is not required on the basis of significant risks to human health. Capping will be considered for source areas above calculated levels that are protective of ground water (areas RA-1, RA-2, and RA-3).

The areal extent of the cap for Alternative SC-2 is presented in Figure 6.1. The extent of coverage exceeds that of the discrete areas represented by subsurface soil areas RA-1, RA-2, and RA-3, as presented in Figure 4.2. Site coverage was increased to improve constructability and reduce the maintenance requirements of the cap. The capped area for Alternative SC-2 is approximately 1.5 acres.

ALTERNATIVE SC-3: Soil vapor extraction

Source areas with chemical levels exceeding calculated levels that are protective of ground water would be remediated through soil vapor extraction (SVE). The areas addressed under this alternative are designated RA-1, RA-2, and RA-3 (Figure 4.3). SVE is

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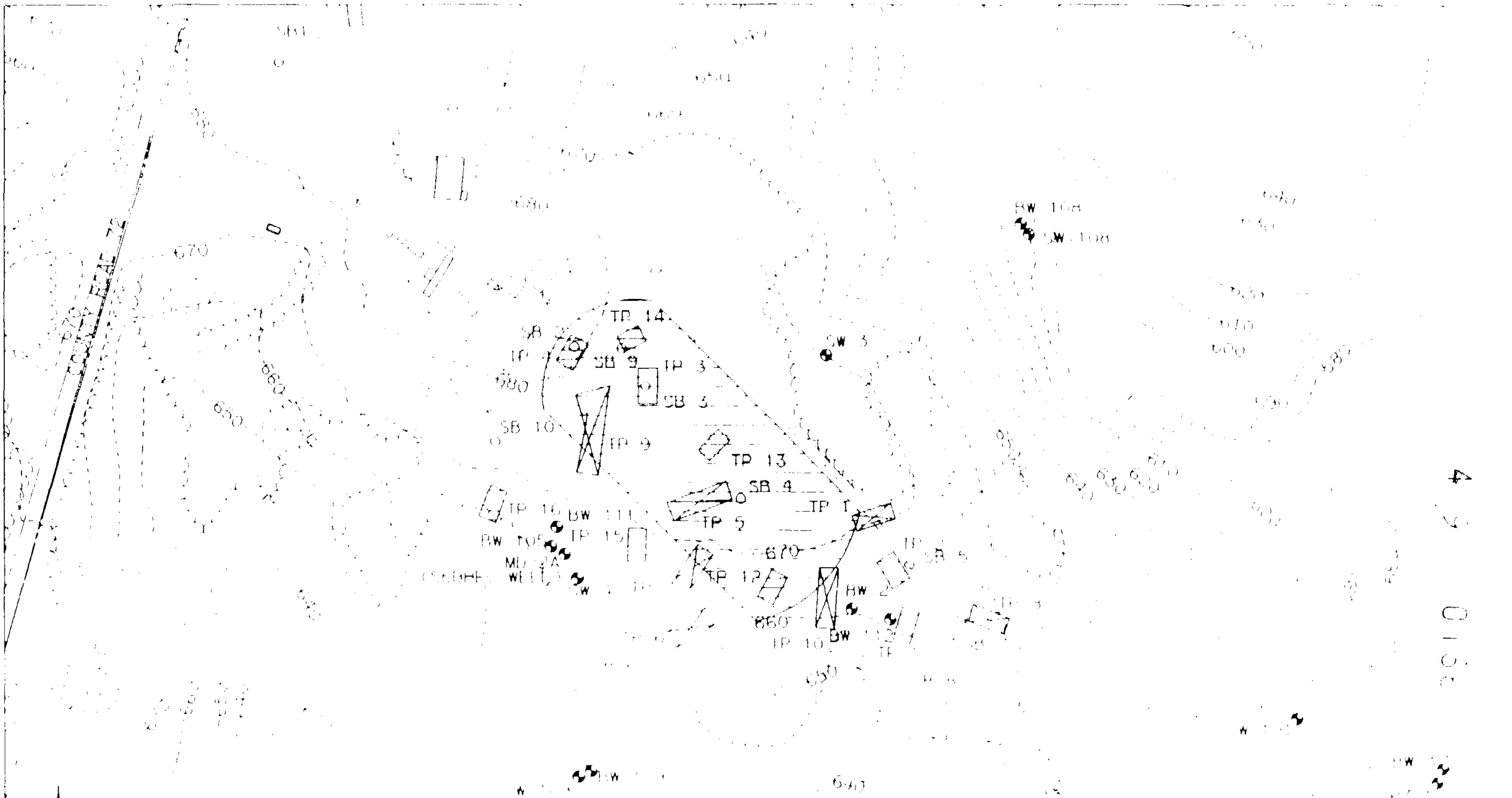

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Greenville, South Carolina

MEDLEY FARM SITE

a demonstrated technology for Site chemicals and geology that will permanently reduce the volume of chemical residuals at the Site.

6.3.3 Preliminary Costs for Alternatives

Preliminary costs for the potential source control and ground water control alternatives are presented in Table 6.2. Alternatives are referenced by the number in Table 6.1. Backup for the preliminary cost estimates is presented in Appendix H.1. Construction and operational costs for the alternatives were developed using the Cost of Remedial Action (CORA) model (EPA, 1990). The approximate level of accuracy for these cost estimates is -50 to +100 percent, as suggested by the EPA document Guidance on Feasibility Studies Under CERCLA (April 1985). Costs were developed on a present worth basis using an interest rate of 5 percent. Costs for ground water control alternatives are based on a 30 year lifetime, the longest allowed under EPA guidance. Projected present worth costs for these alternatives are therefore conservative.

6.4 SCREENING EVALUATION

The assembled alternatives are screened below according to the criteria listed in Section 6.2. Alternatives remaining after this screening will be subjected to detailed analysis in Section 7.

6.4.1 Ground Water Control

ALTERNATIVE GWC-1: No Action

The no action alternative will be retained as required by the NCP. Should the no action alternative be selected, ground water remediation would occur solely through natural processes. Remediation of Site ground water might not be necessary since average concentrations at the nearest potential point of exposure, the property line along Jones Creek, would be below MCLs over the course of a lifetime. Based on these limited

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TABLE 6.2

PRELIMINARY COSTS FOR ALTERNATIVES
MEDLEY FARM SITE

Alternative	Description	Present Worth Costs
GWC-1A	No action for ground water	$100,000
GWC-1B	No action; long-term monitoring	$440,000
GWC-2A	MCLs at Site; air stripping	$1,600,000
GWC-2B	MCLs at Site; activated carbon	$2,500,000
GWC-2C	MCLs at Site; UV/ozone	$2,500,000
GWC-3A	MCLs at property line; air stripping	$1,300,000
GWC-3B	MCLs at property line; activated carbon	$1,900,000
GWC-3C	MCLs at property line; UV/ozone	$1,800,000
SC-1	No action for source areas	$100,000
SC-2	Cap source areas	$810,000
SC-3	Soil vapor extraction	$500,000

potential risks, both no action options will be retained. Alternative GWC-1A would involve no further remedial or assessment activities. Alternative GWC-1B would involve no remedial activities but would include long-term monitoring of Site ground water and deed restrictions

ALTERNATIVE GWC-2: Recovery of all Site ground water exceeding MCLs

Alternative GWC-2 options are differentiated by the process used to treat ground water, namely air stripping, carbon adsorption, or chemical oxidation. Each of the processes is demonstrated as effective for the removal of VOCs to non-detection limits and can be readily implemented using standard construction techniques. The major difference among the Alternative GWC-2 options is the present worth cost. From Table 6.2, the costs for carbon adsorption (GWC-2B) and chemical oxidation (GWC-2C) are significantly higher than for air stripping (GWC-2A). Since these alternatives are equal in effectiveness to air stripping but are significantly more expensive, they are rejected under the cost criterion. Alternative GWC-2A is the only option retained for detailed analysis.

ALTERNATIVE GWC-3: Recovery of all Site ground water that could exceed MCLs at the property line

The differences between the Alternative GWC-3 options are based on the method of ground water treatment and the screening is as described for Alternative GWC-2 above. From Table 6.2, the costs for carbon adsorption and chemical oxidation are significant higher than for air stripping even though they would be no more effective or implementable. Alternative GWC-3B and GWC-3C are therefore rejected from further analysis under the cost criterion. Alternative GWC-3A is the only option retained for detailed analysis.

6.4.2 Source Control

ALTERNATIVE SC-1: No Action

The no action alternative will be retained as required by the NCP. Should the no action alternative be selected, the condition of Site soils would not be expected to change significantly over time. Soils would continue to contribute chemicals to ground water but would present no significant risks to human health.

ALTERNATIVE SC-2: Capping

A cap over the landfill would involve proven technologies and equipment. It would substantially reduce infiltration through the surface materials due to precipitation, thereby reducing chemical levels in any ground water discharge. The cap would also control exposure to surficial soils, although this is not required due to human health considerations.

Capping is a proven effective remedy that can be readily implemented at the Site using standard construction techniques. Alternative SC-2, capping of the source areas exceeding remediation levels, would provide a significant reduction in the contribution of chemicals to ground water and will be retained for detailed analysis. Area of the cap is depicted in Figure 6.1. Capping outside of the indicated area is not necessary for the protection of human health or a further reduction in leachate production.

ALTERNATIVE SC-3: Soil vapor extraction

Soil vapor extraction (SVE) is a demonstrated technology that would permanently reduce the level of volatile organics in Site soils. SVE can be implemented using standard construction techniques. Alternative SC-3 will be retained for detailed analysis.

6.5 SUMMARY OF RETAINED ALTERNATIVES

Alternatives retained after this screening are listed in Table 6.3. These alternatives will be subjected to a more rigorous screening in the detailed analysis (Section 7).

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TABLE 6.3

RETAINED ALTERNATIVES FOR DETAILED ANALYSIS
MEDLEY FARM SITE

GROUND WATER CONTROL	DESCRIPTION
GWC-1A	No action
GWC-1B	Long-term monitoring
GWC-2A	MCLs at Site
GWC-3A	MCLs at property line
SOURCE CONTROL	
SC-1	No action
SC-2	Cap source areas
SC-3	Soil vapor extraction of source areas

7.0 DETAILED ANALYSIS OF ALTERNATIVES

Detailed analysis of alternatives is required by the NCP (40 CFR 300.430(e)(9)). Analysis is divided between source control and ground water control, although a coordinated remedial action would require elements of each.

7.1 EVALUATION CRITERIA

The NCP requirements are eflected in the interim final document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (OSWER Dir. 9335.3-01, October 1988). Nine evaluation criteria are presented that "have proven to be important for selecting among remedial alternatives". These criteria provide the basis for evaluating alternatives and subsequent selection of a remedy. The criteria are:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility or volume of waste
- Short-term effectiveness
- Implementability
- Present worth capital and operating costs
- State acceptance
- Community acceptance

All potential remedial alternatives will be evaluated according to the above criteria, except for State acceptance and community acceptance, which are evaluated separately. Short descriptions of these criteria are given below.

1) Overall protection of human health and the environment. A remedial alternative must adequately eliminate, reduce or control all current or potential risks through identified pathways at a site to be considered for selection. Short-term risks during implementation of an alternative must be within acceptable levels.

2) Compliance with ARARs. Considers action-specific, location-specific and chemical-specific ARARs. CERCLA § 121(d)(4) provides five waivers for ARARs for remedial actions not financed by the Fund. Potential location-specific and chemical-specific ARARs for the Site are presented in Section 4.

3) Long-term effectiveness and permanence. Considers the residual risk following implementation of the alternative, adequacy of process controls, need for replacement of materials during design life.

4) Reduction of toxicity, mobility and volume. Considers type of process, volumes of waste involved, degree of reduction, degree of irreversibility, type/volume of residuals remaining.

5) Short-term effectiveness. Considers factors relevant to implementation of the remedial action, including protection of the community, protection of on-site workers, potential environmental impacts (e.g., air emissions), time required to achieve the remedy.

6) Implementability. Considers ability to construct, reliability of technology, ease of installing additional remedial actions (if required), monitoring considerations, and any regulatory requirements.

7) Present worth costs (capital and operational). Capital cost factors include:

- Mobilization
- Site development
- Equipment purchase and rental

- Engineering and construction management
- Material costs
- Excavation
- Health and safety
- Legal fees and insurance
- Contingency

Operational and maintenance costs reflect the following:

- Equipment repair and replacement
- Labor
- Purchased service costs
- Utilities
- Monitoring and analysis costs
- Disposal costs
- Administrative functions
- Contingency
- Review of remedy every 5 years, as required by SARA.

8) State acceptance. Assesses State concerns. As part of a cooperative agreement with the USEPA, State acceptance will be incorporated into the FS as part of the document review process.

9) Community acceptance. Assesses community concerns. Public comments will be made on the Final Feasibility Study and incorporated into the responsiveness summary of the Record of Decision.

Accuracy of the present worth costs for the detailed analysis is +50/-30 percent, per EPA guidance. The feasibility level cost estimates given with each alternative have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final project schedule, and other variable factors. As a result, the final project costs may vary from the estimates presented herein.

A discount rate of 5 percent is used and inflation is taken to be 0 percent. A sensitivity analysis will be used when sufficient uncertainty exists regarding the design, implementation, operation or effective life of an alternative.

Costs for long-term ground water monitoring on a biannual basis (estimated) and review of Site remedy every five years are given with each alternative. These elements will be required for any remedial action that is selected where residuals remain at the Site. Present worth costs for these items are based on 30 years of operation, the maximum time allowed by EPA guidance. This approach provides conservative estimates of cost.

Schedule estimates are based on projected availability of materials and labor and may have to be updated at the time of remediation. Construction schedules are based on good weather, the ability to create and receive adequate and authorized access, and the availability of required utilities. All time estimates assume that the selected Remedial Design, including construction drawings, have been approved and all negotiations with contractors have been concluded.

7.2 GROUND WATER CONTROL

Ground water control refers to chemical migration in ground water at the Site. Potential remedial requirements for ground water were described in Section 4.2.1.

7.2.1 Alternative GWC-1: No Action

The no action alternative includes no remedial action measures and assumes that Site ground water would migrate as modeled in Section 4.3.1. The NCP requires that the no action alternative be retained through detailed screening of alternatives as a baseline for comparison.

For the Site, there are two options under the no action alternative. Alternative GWC-1A would involve no further activities at the Site other than a review of remedy every five years. Alternative GWC-1B would add long-term monitoring of ground water and deed restrictions. Detailed analysis of the alternatives is presented below.

7.2.1.1 Alternative GWC-1A: No Further Activities

Site conditions would remain unchanged under this alternative. Existing monitoring wells would be retained as is for potential use although no ground water monitoring is included under this alternative. A review of remedy would be conducted every five years.

Overall Protection of Human Health and the Environment

The no action alternative would be protective of human health and the environment under current conditions. The baseline risk assessment determined that Site ground water currently poses no risks to human health since there are no receptors. Potentially significant risks to human health (1.1×10^{-2}) could occur in the future if a potable well were constructed at the Site. This hypothetical risk exceeds the acceptable exposure level range of 10^{-4} to 10^{-6} specified in the NCP (40 CFR 300.430 (e)(i)(A)(2)). The existing public water supply and lack of development in the area make the potential for construction of a potable well minimal.

The only potential impact of Site ground water on environmental populations would be through discharge to Jones Creek in the future. Projected ground water concentrations at Jones Creek are compared with Federal Ambient Water Quality Criteria (AWQC; EPA, 1986) in Table 7.1. Site concentrations at Jones Creek are significantly below AWQC and ground water discharge should pose no significant risks to the environment. The assessment is conservative because all Site ground water does not discharge to Jones Creek and because dilution in the creek is not considered.

Compliance with ARARs

Potential chemical-specific and location-specific ARARs are presented in Section 4.1. Because no remedial actions are included in this alternative, there are no action-specific ARARs.

Ground water beneath the Site is considered a current source of drinking water (Class GB under the State classification system and Class II A under EPA's Ground Water Classification Guidelines). Standards that are potentially ARAR for Site ground water are Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act (40 CFR 141.11).

EPA generally considers MCLs to be the most appropriate remediation level for Class II A ground water. Site ground water exceeds MCLs. Based on this preliminary evaluation of ARARs, Site ground water exceeds potential remediation levels and the no action alternative would not satisfy ground water ARARs across the site without a waiver (CERCLA Part 121(d)(4)). MCLs would be more appropriately applied at the potential point of exposure, which would be the property line along Jones Creek. Average concentrations at the property line in the future would be below MCLs (Table 4.7). The no action alternative would therefore comply with ARARs at the property line.

No endangered species or areas of significant historical importance were identified at the Site. The no action alternative therefore does not violate any location-specific ARARs.

Long-term Effectiveness and Permanence

The magnitude of residual risks at the Site would remain unchanged under the no action alternative. Since waste residuals would remain at the Site, review of the effectiveness and

TABLE 7.1

ESTIMATED SURFACE WATER DISCHARGE LEVELS

Compound	AWQC (mg/l)	Maximum Ground Water Concentration at Jones Creek (mg/l)	Maximum In-Stream Conc. (mg/l)
1,1-Dichloroethane	NA	0.001	0.02
1,2-Dichloroethane	20.0	0.002	0.04
1,1-Dichloroethene	11.6[a]	0.02	0.3
1,2-Dichloroethene (total)	11.6[a]	0.0003	0.004
1,1,1-Trichloroethane	18.0[a]	0.02	0.5
1,1,2-Trichloroethane	9.4	0.0001	0.002
Trichloroethene	21.9	0.006	0.1
Tetrachloroethene	0.84	0.002	0.03
Chloroform	1.24	0.0001	0.001
Methylene chloride	NA	0.001	0.02

Ambient water quality criteria (Quality Criteria for Water, EPA, 1986) represent chronic values, where available. The in-stream concentration represents mixing of the maximum ground water concentrations given in Table 4.6 without treatment at a rate of 30 gpm (Alternative MC-2A) with the 7Q10 flow of Jones Creek of 0.5 cfs (200 gpm). In-stream concentrations for Alternative MC-3A (15 gpm) would be one-half of those presented here.

[a] - Acute value, no chronic data available
NA - No AWQC available.

protectiveness of the no action alternative every five years would be required by SARA. Conditions at the Site are not anticipated to change significantly over a five year period.

Reduction of Toxicity, Mobility or Volume

This alternative would not significantly reduce the toxicity, mobility or volume of Site residuals. A slight level of remediation may occur through natural processes such as biodegradation and adsorption. Site-related chemicals would remain in the ground water and have the potential to discharge into Jones Creek under this alternative, although such discharge presents no significant risks.

Short-term Effectiveness

This alternative presents no risks to the community, on-site workers or the environment due to implementation. The no action alternative can be implemented immediately. Since no remedial actions are included, there is no schedule of completion.

Implementability

The no action alternative can be readily implemented. The no action alternative would not hinder the implementation of any remedial actions in the future.

Cost

This alternative involves no capital costs. Operating costs are review of the Site conditions every five years. There would be no maintenance costs.

The detailed cost estimate for this alternative is presented in Appendix H.2. A summary of the estimated costs is given below:

Total Construction Costs -	$0
Present Worth O&M Costs -	$140,000
Total Present Worth Costs -	$140,000

7.2.1.2. Alternative GWC-1B: Long-term monitoring of Site ground water

This alternative is an extension of Alternative GWC-1B in that long-term monitoring of Site ground water and deed restrictions would be added. For purposes of the FS, a maximum of four additional monitoring wells would be constructed. Sampling here is assumed to be a biannual event with analyses for VOCs. The adequacy of the existing well portfolio and sampling frequency would be established during Remedial Design. Deed restrictions would be used to limit potential uses of ground water on the Medley property as a conservative measure, although they would not be required based on human health considerations.

Evaluation of the no action portion of this alternative would be as described for Alternative GWC-1A (Section 7.2.1.1.). The evaluation here will focus on the additional requirements and considerations associated with long-term monitoring and deed restrictions.

Overall Protection of Human Health and the Environment

Deed restrictions would be used to reduce the minimal potential for creation of a potable well at the Site. The remainder of the evaluation under this criterion would be the same as for Alternative GWC-1A (Section 7.2.1.1.).

Compliance With ARARs

Monitoring of Site ground water wells would help verify that average concentrations at the property line were below MCLs. The remainder of the evaluation under this criterion would be the same as for Alternative GWC-1A.

Long-term Effectiveness and Permanence

The magnitude of risks at the Site would remain unchanged under this alternative. Periodic monitoring of Site ground water would be conducted to evaluate the potential for risks in the future. Institutional controls might be necessary to prevent any future use of ground water influenced by Site activities, although the availability of a municipal water supply indicates that potential ground water uses are unlikely.

Since waste residuals would remain at the Site, review of the effectiveness and protectiveness of the no action alternative every five years would be required by SARA. Conditions at the Site are not anticipated to change significantly over a five year period.

Reduction of Toxicity, Mobility or Volume

Evaluation under this criterion would be the same as for Alternative GWC-1A.

Short-term Effectiveness

This alternative presents no risks to the community, on-site workers or the environment due to implementation. The no action alternative can be implemented immediately following the installation of any additional monitoring wells. Installation of the four monitoring wells assumed for use in the FS would require approximately one month.

Implementability

Numerous monitoring well have been installed at the Site. Construction of additional wells, if necessary, would pose no significant technical concerns. Ground water discharge is the sole migration pathway and this can be readily monitored using the existing observation wells. The no action alternative would not hinder the implementation of any remedial action in the future.

The no action alternative would require institutional controls to govern future use of the Site. The adequacy of these controls to protect human health and the environment should be evaluated periodically to maintain effectiveness.

Cost

Capital costs include the construction of up to four additional monitoring wells, although the adequacy of the existing portfolio would be evaluated during Remedial Design. Operating costs include periodic sampling of select monitoring wells, chemical analyses, reporting and review of the Site conditions every five years. Maintenance costs would include inspection of the monitoring wells.

The detailed cost estimate for this alternative is presented in Appendix H.2. A summary of the estimated costs is given below:

Total Construction Costs -	$ 35,000
Present worth O&M Costs _	$750,000
Total Present Worth Costs -	$790,000

7.2.2 Alternative GWC-2A: All Ground Water Above MCLs

This alternative involves the recovery of all Site ground water currently exceeding MCLs through a well point extraction system. The total extracted flow rate is anticipated to be approximately 30 gpm. The projected extraction system layout is presented in Figure 4.1. Extraction wells would be screened in the bedrock transition zone for optimal recovery of ground water. Capture zone effectiveness would be evaluated through aquifer response measurements conducted during construction of the overall extraction system.

For purposes of the FS, discharge of ground water would be to Jones Creek. Lagoon water that was treated during the immediate removal action was discharged to Jones Creek. South Carolina does not have established State standards for surface water discharge of chlorinated VOCs and defers to Federal Ambient Water Quality Criteria (AWQC). The AWQC are conservative estimates for the protection of aquatic life. AWQC for compounds in the Site ground water are presented in Table 7.1.

Allowable discharge levels would be based on blended exposure concentrations in the surface water. The weekly low flow rate over a ten year period (7Q10) for Jones Creek is 0.5 cubic feet per second (cfs), or 200 gallons per minute (gpm). Instream blended concentrations based on the estimated ground water concentrations at a flow rate of 30 gpm are presented in Table 7.1. Without any treatment, Site ground water could be discharged directly to Jones Creek and be protective of aquatic life, as determined by Federal AWQC. To be conservative and to apply a factor of safety, ground water would be air stripped prior to discharge for the FS evaluation.

The ground water treatment system would involve the following elements:

- manifolding of the extraction well piping to a common treatment area
- concentration equalization and sediment collection
- air stripping column with blower
- transfer pumps
- flow measurement and sampling
- discharge line to outfall on Jones Creek.

The conceptual flow diagram is presented in Figure 7.1.

Protection of Human Health and the Environment

The baseline risk assessments determined that there are currently no risks to human health or the environment posed by Site ground water. Remediation of ground water to MCLs would be protective of human health in the future should Site ground water be used for potable water. The existing municipal water supply and lack of projected development in the area indicate that future uses of Site ground water are unlikely.

Compliance with ARARs

MCLs are identified as potential ARARs for Site ground water. This alternative would attain MCLs and therefore comply with ARARs. Discharge of ground water to Jones Creek would satisfy AWQC, even without treatment.

Long-term Effectiveness and Permanence

Extraction wells would achieve removal of ground water for subsequent treatment. Ground water recovery via extraction wells and submersible pumps is a proven technology that has a high degree of reliability. Maintenance consists of periodic inspection of the wells, pumps and control units.

Air stripping is an effective and reliable process for achieving high removal levels of VOCs from ground water. Based on the Henry's law constants in Table 4.7 and maximum ground water concentrations in Table 4.6, a single stage air stripper will be capable of achieving

Figure 7.1

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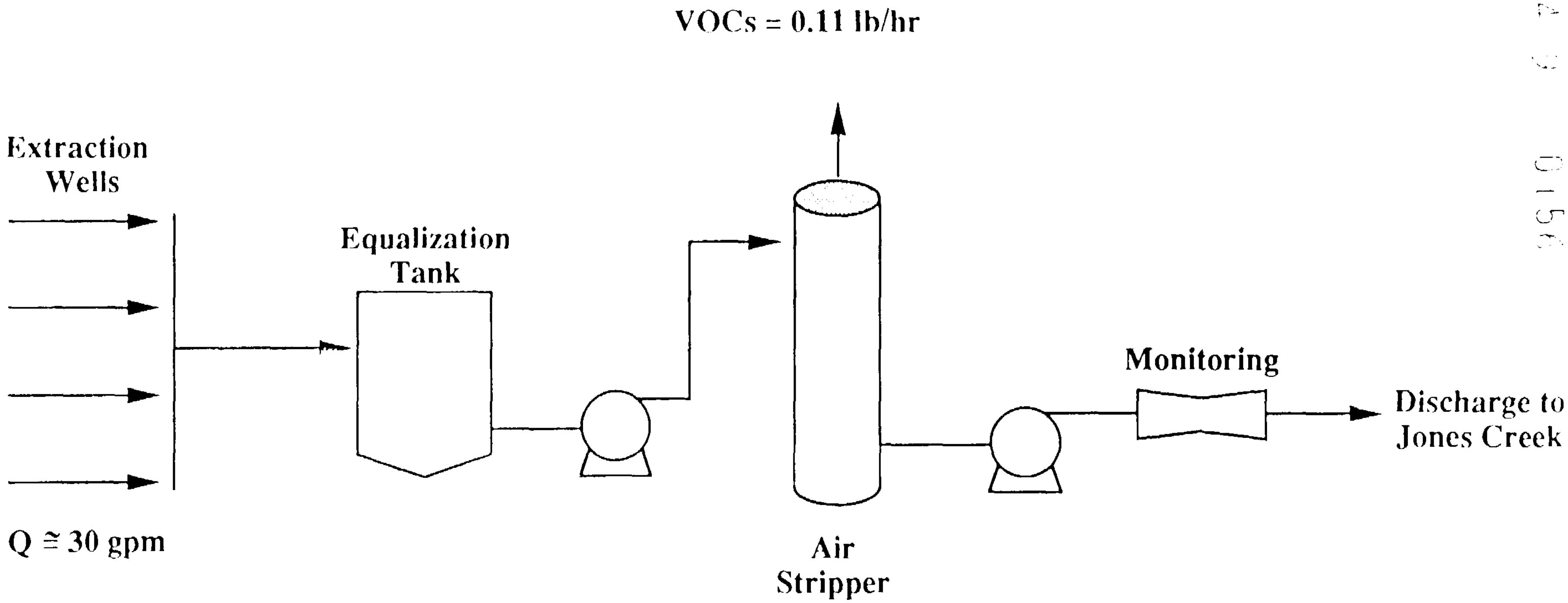

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Figure 7.1
Groundwater Treatment Flow Diagram
Alternative GWC-2A

the projected discharge levels to Jones Creek. Maintenance consists of periodic inspection of the packing, blower and transfer pumps. Structured packing can limit the potential for scale formation and the associated reductions in VOC removal efficiency.

Effluent from the ground water treatment system would satisfy all discharge requirements and would not adversely impact Jones Creek. Periodic effluent sampling would be required.

Ground water would be taken to essentially background levels, since pumping would continue until MCLs were achieved for all compounds. A five-year review of remedy would therefore not be required once the remediation levels were achieved.

Reduction of Toxicity, Mobility, or Volume

Ground water extraction would reduce the volume of chemicals at the Site while the subsequent treatment would reduce the toxicity of ground water prior to discharge. The mass of VOCs in ground water would be reduced by more than 99 percent. Air stripping of ground water would comply with SARA's preference for remedies involving treatment.

Short-term Effectiveness

Installation of extraction wells would pose no health risks to the community. On-site workers can be protected from potential risks through adherence to the remedial health and safety plan. Construction of the ground water treatment facility would pose no risks to the community or workers. Emissions from the air stripper would pose no significant risks to the community or workers (Appendix G).

Installation of the extraction wells and subgrade utilities would take approximately two months. Installation of the ground water treatment system and construction of a discharge line to Jones Creek would require approximately three months and could occur simultaneously with other remedial activities.

The time to achieve remediation levels cannot be accurately estimated due to adsorption and hysteresis effects upon mass transfer chemistry between soils and ground water. The estimated time to achieve MCLs based on a batch flushing model (EPA, 1988) would be approximately eight to ten years.

Implementability

Numerous monitoring wells have been constructed at the Site and no difficulties are anticipated in construction of the extraction wells. Distribution lines to the ground water treatment system would be below grade and heat traced to prevent potential freezing where placed above the frost line.

Installation of an air stripper at the anticipated flow rate would have no special installation requirements and the ground water treatment system should be readily constructed. Design of the treatment could not be completed until the surface water discharge requirements were defined with the State personnel.

Cost

Construction costs associated with this alternative include mobilization; extraction wells and the ground water distribution system; the ground water treatment system; discharge line to Jones Creek; upgrading the Site roads; and utility connections. Operating costs include power and maintenance for the extraction wells; labor, power and sampling for the treatment system; and ground water monitoring. Sampling is assumed to be a biannual event focused on indicator parameters. Maintenance costs include facility inspections and equipment repair.

A sensitivity analysis can be applied to detailed cost estimates when there is sufficient uncertainty associated with a key independent variable. For groundwater control alternatives, a primary factor affecting long-term operations and maintenance costs (O&M) is the duration of remedial activities. Detailed cost estimates are typically based on 30 years of operation, the maximum costing period allowed under EPA guidance. The 30 year period generates conservative estimates of present worth costs.

The actual period for groundwater extraction is problematic because subsurface desorption kinetics are difficult to quantity. A batch flushing model (EPA, 1988) is one method to estimate the duration of groundwater extraction. Based on calculations presented in Appendix B, Alternative GWC-2A should require approximately 10 years to achieve MCLs. Detailed estimates based on operation for 30 years and for the modeled duration are presented in Appendix H.2 and summarized below.

	DURATION	
	30 Years	10 Years
Total Construction Costs -	$ 610,000	$ 610,000
Present Work O&M Costs -	$1,250,000	$ 630,000
Total Present Worth Costs -	$1,900,000	$1,200,000

The apparent difference in present worth costs is likely exaggerated since case histories and technical literature indicate that predictions of aquifer restoration periods are generally under estimated.

7.2.3 Alternative GWC-3A: MCLs at the Property Line

This alternative involves the recovery of ground water such that MCLs would not be exceeded at the property line. The projected extraction system layout is presented in Figure 4.2. The total extracted flow rate is anticipated to be approximately 15 gpm. Discharge requirements and treatment system design would be as for Alternative GWC-2A (Section 7.2.2). The detailed analysis will focus on any significant differences between the alternatives and summarize any similarities.

Protection of Human Health and the Environment

Site ground water currently poses no risks to human health. A potential point of human exposure to Site ground water is at the Medley property line along Jones Creek. Remediating the ground water to MCLs would be protective of human health in the future should a potable well be installed at the property line, since MCLs represent allowable "at the tap" concentrations.

Site ground water currently poses no risks to the environment. Maximum Site discharge concentrations to Jones Creek in the absence of remediation would be more than one hundred times below AWQC. Remediation of ground water to MCLs at the property line would reduce in-stream concentrations even further.

Compliance with ARARs

MCLs would be met at the potential point of exposure (the property line) under this alternative. Since MCLs are intended to be applied "at the tap", the property line is the most appropriate point of their application at the Site. This alternative therefore complies with ARARs.

The extraction wells would be constructed to conform to South Carolina standards. Emissions from the air stripper would comply with South Carolina allowable air exposure levels without any off-gas control (SCDHEC Air Pollution Control Regulation No. 62.5, Standard No. 8; Appendix G). Discharge of ground water to Jones Creek, with or without treatment, would satisfy AWQC (Table 7.1) and the substantive aspects of an NPDES permit as administered by SCDHEC.

Long-term Effectiveness and Permanence

Projected concentrations at the property line based on conservative modeling would be below MCLs. Effectiveness of this alternative can be assessed through periodic ground water monitoring of VOCs and water level measurements. Placement of any additional monitoring wells would be determined in the Remedial Design.

Ground water recovery through well point extraction and treatment by air stripping are proven processes with a high degree of reliability. Operation would include regular inspections and effluent monitoring. The required maintenance would present no technical concerns.

Reduction of Toxicity, Mobility or Volume

The principal threat to human health from Site ground water, potential exposure at the property line, would be addressed under this alternative. The volume and potential toxicity of Site ground water would be significantly reduced under this alternative. The total mass of VOCs in ground water would be reduced by more than 95 percent.

Short-term Effectiveness

Construction and operation of this alternative would represent no significant risks to on-site workers or to the community. A health and safety plan would be implemented to cover all aspects of remedial activities.

Implementation time for this alternative would be the same as for Alternative GWC-2A (Section 7.2.2). The time to achieve remediation levels cannot be accurately estimated due to adsorption and hysteresis effects upon mass transfer chemistry between soils and ground water. The estimated time for ground water extraction such that MCLs are achieved at the property line, based on a batch flushing model (EPA, 1988), would be approximately five to six years.

Implementability

Implementation of this alternative would be the same as for Alternative GWC-2A (Section 7.2.2).

Cost

Construction and operating cost elements associated with this alternative would be the same as for Alternative GWC-2A (Section 7.2.2). The actual period for groundwater extraction is problematic because subsurface desorption kinetics are difficult to quantify. A batch flushing model (EPA, 1988) is one method to estimate the duration of groundwater extraction. Based on calculations presented in Appendix B. Alternative GWC-3A should require approximately 6 years to achieve MCLs. Present worth O&M costs were estimated for 6 years of operation to support a sensitivity analysis. Detailed estimates based on operation for 30 years and for the modeled duration are presented in Appendix H.2 and summarized below.

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	DURATION	
	30 Years	6 Years
Total Construction Costs -	$ 520,000	$ 520,000
Present Worth O&M Costs -	$ 770,000	$1,160,000
Total Present Worth Costs -	$1,300,000	$1,700,000

The apparent difference in present worth costs is likely exaggerated since case histories and technical literature indicate that predictions of aquifer restoration periods are generally under estimated.

7.3 SOURCE CONTROL

The purpose of source control is to address chemical residuals in soils that could cause ARARs to be exceeded in ground water through leaching. Source control (SC) alternatives will be considered for soils at the Medley Farm Site that could contribute chemical levels to ground water exceeding MCLs (Figure 4.3). Retained alternatives are presented in Table 6.3. The detailed analysis of these alternatives is presented below.

7.3.1 Alternative SC-1: No Action

The immediate removal action conducted at the Site involved the following activities:

- draining and crushing 5,383 drums and containers
- incineration of 24,200 gallons of bulked liquids collected from the drums
- landfilling of 2,132 cubic yards of contaminated soils at a secure landfill
- treatment of 70,000 gallons of water from the six lagoons followed by discharge to Jones Creek.

The RI found limited levels of chemical residuals remaining at the Site, indicating that the great majority of residuals formerly at the Site were removed under the immediate removal action. Under the no action alternative, no further remedial activities would occur.

Deed restrictions could be placed on future uses of the Medley property to prevent inadvertent exposure to any chemical residuals. Future uses of the property are considered unlikely given lending restrictions on former hazardous waste disposal areas.

Overall Protection of Human Health and the Environment

The baseline risk assessments determined that Site soils did not pose a significant risk to human health. Risks from soils to environmental populations could not be quantified but are limited because most of the surface soil is clean fill and animals do not feed exclusively at the Site. The no action alternative for Site soils would therefore be protective of human health and the environment.

Compliance with ARARs

The only identified ARAR for Site soils is the TSCA remediation level of 10 mg/kg for PCBs in areas of unrestricted access. All Site soils are less than the 10 mg/kg TSCA level. There are no identified ARARs for the remaining Site chemicals in soils. All Site soils are less than the site-specific remediation level for PCBs in surficial soils of 5.5 mg/kg. Based on unsaturated transport modeling (Appendix D), soils at three locations are calculated to have the potential to cause Site ground water to exceed MCLs.

Potential location-specific ARARs are presented in Section 4.1. No endangered species or areas of significant historical importance were identified at the Site. The no action alternative therefore does not violate any location-specific ARARs. There are no action-specific ARARs for this alternative.

Long-term Effectiveness and Permanence

Potential migration pathways for chemicals in Site soils are surface run-off and unsaturated transport to ground water. The RI determined that chemical migration via surface run-off was not significant. VOCs are the only Site chemicals with the potential to impact ground water above MCLs.

Since waste residuals would be left at the Site, review of the effectiveness and protectiveness of the no action alternative every five years would be required by SARA. Conditions at the Site are not anticipated to change significantly over a five year period.

Reduction of Toxicity, Mobility or Volume

This alternative would not significantly reduce the toxicity, mobility or volume of remaining Site residuals. A slight level of remediation may occur through natural processes such as biodegradation, adsorption and volatilization.

Short-term Effectiveness

This alternative presents no additional risks to the community, on-site workers or the environment due to implementation. The no action alternative can be implemented immediately.

Implementability

The no action alternative could be readily implemented and would not hinder the implementation of any remedial actions in the future. No Site maintenance would be required.

The no action alternative could require institutional controls to govern future use of the Site. The adequacy of these controls to protect human health and the environment could be evaluated periodically to establish their effectiveness.

Cost

There are no construction costs. Operating costs would involve a review of remedy every five years. The detailed cost estimate for this alternative is presented in Appendix H.2. A summary of the estimated costs is given below:

Total Construction Costs -	$ 0
Present Worth O&M Costs -	$140,000
Total Present Worth Costs -	$140,000

7.3.2 Alternative SC-2: Cap Source Areas

This alternative involves construction and operation of a low permeability cap over Site soils. A cap would essentially deny infiltration (Appendix I). Limiting infiltration would significantly reduce the potential for transport of chemicals to ground water and reduce the ground water extraction rates necessary to control migration. To be conservative, the estimated extraction rates given for Alternatives GWC-2A and GWC-3A based on existing conditions would be maintained for the FS should one of those alternatives be selected in conjunction with Alternative SC-2.

Construction of a cap involves the use of heavy earth moving and grading equipment. Existing access may have to be improved for optimal use of this equipment. The landfill area requires clearing of trees and large brush. Vegetation and stumps would be grubbed below the surface to prevent regrowth. Ground water observation wells not needed for long-term monitoring would be abandoned following the procedures used in the RI. Fill would be imported to the Site and compacted to form a sloped base for the cap. The cap would be constructed of a single layer synthetic liner over the compacted sub-base.

A multi-layer cap including compacted clay, as specified under RCRA, is not felt to be appropriate for the Site. EPA's Hydrological Evaluation of Landfill Performance (HELP) model was used to evaluate caps based on the following low permeability barriers:

- 40-mil high density polyethylene (HDPE) liner and one foot of compacted clay
- 60-mil HDPE liner

The model determined that there was no significant differences in performance of the two capping systems (Appendix H). Shipping the required quantities of clay to the Site would increase costs without increasing the effectiveness of the remedy. The long-term reliability of synthetic liners is well established (Gundle, 1990) and a redundant barrier should not be necessary. Single synthetic liners have been approved to cap areas at other CERCLA sites in Region IV (Sirrine, 1990). A 60-mil HDPE liner would therefore be the most appropriate low permeability barrier for a Site cap. For purposes of the Feasibility Study, the Site cap would consist of a compacted sub-base of common and select fill, 60-mil HDPE liner, drainage net, filter fabric, soil cover and vegetation. A typical cross-section is presented in Appendix H. Permeability of the cap would be approximately 1×10^{-13} cm/s (Gundle, 1990). Actual design and materials of construction would be determined in the Remedial Design phase, should a capping alternative be selected for implementation.

Drainage swales would be constructed along the cap perimeter to control surface run-on and direct cap run-off. A security fence would be constructed along the perimeter of the cap to deter unauthorized access.

Placement of the cap would be as presented in Figure 6.1. Materials beneath the cap would consist of saprolitic soils containing low levels of chemical residuals. These soils are well consolidated and substantial settling beneath a cap is not anticipated. Markers could be placed on the cap to define any settlement. Chemical residuals in general are not particularly biodegradable and are present at low concentrations. Appreciable gas generation beneath the cap would not be anticipated.

Overall Protection of Human Health and the Environment

Site soils do not represent a significant risk to human health. Placing a cap above Site residuals would significantly reduce their leaching potential through infiltration and thus limit the potential future risks presented by ground water. A reduced leaching potential would translate into lower chemical loadings into ground water, hence lower risks to potential downgradient receptors in the future. A cap would also control any chemical migration through surface runoff, although this potential is considered slight.

Vegetative uptake was identified in the baseline risk assessments as a potential but limited risk. Removal of existing vegetation and capping the major source areas at the Site would eliminate this exposure pathway.

Concentrations of site-related chemicals found in surface soil samples outside of the cap represent potential risk levels of less than 10^{-6} and are not significant. No soils outside of the cap have the potential to impact ground water above MCLs.

Compliance with ARARs

Disposal of wastes was discontinued in 1976, prior to the effective date of RCRA (November 19, 1980). Consolidation of waste materials within a unit and capping in place does not trigger RCRA disposal requirements (EPA, 1988). RCRA treatment and disposal requirements are therefore not ARARs for capping at the Site. The single synthetic liner design would still meet an equivalent standard of performance to RCRA (40 CFR 264.310), as follows:

i) provide long-term minimization of migration of liquids
ii) function with minimum maintenance
iii) promote drainage and minimize erosion or abrasion of the cover
iv) accommodate settling and subsidence to maintain cover integrity
v) have a permeability less than that of natural subsoils.

Actual design requirements would be specified during Remedial Design.

All construction activities would take place above the 100-year flood plain. The Health and Safety Plan governing all remedial activities would conform to 29 CFR 1910.120.

Capping the Site would result in a fenced, sloped area overlying a synthetic liner, which would discourage future uses. Deed restrictions could be included in the implementation of this alternative as a secondary control measure to prevent uses of the Site that could reduce the effectiveness of remedial measures.

Long-term Effectiveness and Permanence

Potential risks at the Site would only occur in the future through chemical transport to ground water. Chemical transport following construction of a cap would be significantly less than under current conditions. Remaining risks associated with chemical residuals outside of the cap would not be significant.

Leakage due to permeation of synthetic membrane liners is not significant i omparison to flow through holes created during construction or installation (Bonaparte, 1989). Use of a 60 mil liner would limit the potential for pin holes to be formed during manufacturing. Vacuum testing of seams in the field would provide excellent quality assurance and control the only other potentially significant avenue of cap leakage.

Long-term stability of the cap should be excellent with regular inspections and maintenance. Underlying Site materials are primarily inert and minimal settling or generation of gases is anticipated. Synthetic liners can accommodate slight settling due to their resiliency. Periodic inspections would be required to check for erosion, settling and conditions of the drainage system. Deterioration of cap integrity must be identified and corrected quickly to maintain effectiveness. The integrity of the fence must also be maintained to deter unauthorized access. An established inspection and maintenance schedule would be implemented following construction and continued for as long as chemical residuals remained at the Site. Regular care of the cap system would preserve its effectiveness indefinitely.

Caps have been constructed at numerous CERCLA sites with excellent results. Proper construction and regular maintenance would allow a perpetual operating life. Future replacement, if required, should be straightforward since the earthwork has already been completed and would isolate residuals during construction. Potential risks are considered minimal should elements of the cap require repair or replacement.

Evaluating the effectiveness of this alternative could be performed through periodic ground water monitoring. Test vents might be required to estimate gas generation potential within the landfill. This potential is considered slight based on the materials in the landfill.

Since landfill residuals would remain at the Site, review of the effectiveness and protectiveness of this alternative every five years would be required by SARA. Inspection and maintenance records for the cap would be reviewed at this time. Conditions at the Site are anticipated to improve with placement of the cap.

Reduction of Toxicity, Mobility, or Volume

The mobility and potential exposure of chemicals above the water table would be greatly reduced under this alternative. The mobility of chemicals below the water table would not change significantly. There would be no reduction in toxicity or volume of site-related chemicals. Risks due to residuals remaining at the Site would not be significant.

Short-term Effectiveness

Grubbing and grading of the Site would be necessary for construction of the cap. Dust control would be exercised to minimize the potential release of air-borne particulates. Worker safety can be controlled through adherence to the remedial Health and Safety Plan.

Construction of the cap could not begin until all materials are available and adequate access had been developed. Implementation time would depend on the number of crews involved but should be approximately 3 months. This schedule assumes standard production rates and compliance with all inspections of performance requirements and workmanship. Adverse climatic conditions could hinder construction performance and delay the schedule. Construction should be scheduled to allow vegetation immediately after final grading.

Implementability

Construction of a cap is a straightforward operation that has been accomplished at numerous waste sites. Clearing of the Site and establishment of access for heavy machinery should pose no difficulties. Caps have been successfully implemented at other CERCLA sites.

The maximum slope that would have to be capped would be approximately 10 percent, at the south end of the cap. This slope would require the use of a textured liner, enhanced anchor support, and an erosion mat for vegetation. These requirements would involve additional engineering and construction measures but represent no significant implementation difficulties.

The availability of common and select fill material should be adequate but procurement and transportation may limit construction activities. A drainage system would have to be constructed along the perimeter of the cap. The drainage system would collect only rainwater, which would be redirected to the land surface. Cover design would have to consider possible freezing in the drainage system during winter.

Liner installation would have to be scheduled for suitable climatic conditions. Seams may be welded under freezing conditions but not during periods of precipitation. Final construction should allow for vegetation during the growing season. Hauling the required quantities of materials to the Site may impact traffic patterns and cause road wear. A staging area would be required outside of the area to be capped.

Lead time for the HDPE liner and geotextile materials is approximately one month and competitive sources should be available. Identification of the common and select fill sources would be the single greatest lead item. Cap construction is a common remedial measure and there should be a number of qualified bidders.

Cost

Construction costs associated with this alternative include mobilization, excavation, grubbing, grading, earth work, materials, and labor. Operating costs include maintenance of the cap, reporting and review of the Site remedy every five years. Sampling is assumed to be a biannual event focused on indicator parameters. Maintenance costs include periodic inspections and grounds keeping.

The detailed cost estimate for this alternative is presented in Appendix H.2. A summary of the estimated costs is given below:

Total Construction Costs -	$580,000
Present Worth O&M Costs -	$420,000
Total Present Worth Costs -	$1,000,000

7.3.3 Alternative SC-3: Soil Vapor Extraction

Soil vapor extraction (SVE) would be applied to the three areas (RA-1, RA-2, and RA-3) identified in Figure 4.3. VOCs are the only compounds in Site soils with the potential to cause ground water to exceed MCLs. Upon completion of SVE activities, there would no longer be a significant source of chemicals to impact ground water.

Construction of an SVE system at the Site would involve the following activities:

- system design based on soil and chemical properties
- connection of subgrade utilities (440 volt, 3 phase service)
- installation of 4-inch PVC slotted well screen down to the water table at predetermined locations to form the extraction system
- manifolding of the individual screen headers to the vacuum system
- connection of the emissions control system (activated carbon filters)
- startup, followed by monitoring of the individual headers and combined system to assess the effectiveness of VOC removal and refine operation as necessary.

SVE extraction wells would be installed using standard drilling equipment (e.g., hollow-stem augers). A filter pack would be placed around the screen and a grout seal would be placed at the well surface.

The SVE vacuum system would be self-enclosed and designed to operate unattended. A 30-40 HP unit would likely be required for the Site. All wiring would be explosion proof. Silencers would be placed on the vacuum blower intake and outlet to minimize noise in the community. Any entrained water would be collected in a knock out drum and either stored for off-site disposal or sent to the ground water treatment system.

The system would be manned during startup until proper operation of the equipment was verified and the required subsurface air flow rates were established. VOC emissions from each header and for the total system would be measured to evaluate removal rates and establish that air emissions were within protective levels. After achieving equilibrium, the system would be checked monthly for equipment maintenance, air flow rates and VOC emissions. The system would contain an automatic interrupt and telephone dialer in the event of equipment malfunction.

Target remediation levels for SVE at the Medley Farm Site would be the VOC levels specified in Table 4.3. The effectiveness of SVE in the removal of VOCs from Site soils would be evaluated through periodic sampling of the air emissions. Soil borings might be required to confirm that the VOC remediation levels had been achieved. To be conservative, confirmation soil borings have been included in the FS cost estimates.

A potential benefit of SVE at the Site would be the removal of SVOCs. SVOC levels at the Site do not pose a risk to human health or the environment and cannot impact ground water above remediation levels. Accordingly, SVOCs are not targeted for removal during SVE. However, SVE would incidentally remove SVOCs as part of the primary objective of VOC removal. Removal would be effected through either enhanced biodegradation due to increased oxygen levels in the subsurface or through direct volatilization, as discussed in Section 5.4.2. Biodegradable compounds such as phthalates would be likely to be biodegraded while moderately volatile compounds such as chlorinated benzenes would be volatilized.

Overall Protection of Human Health and the Environment

The baseline risk assessment determined that Site soils do not pose a significant risk to human health or the environment. VOCs are the only compounds with the potential to cause ground water to exceed MCLs. VOC levels in Site soils would be below calculated remediation levels at the close of SVE activities and would no longer pose a risk to ground water. Operation of the SVE system would satisfy South Carolina ambient air requirements. This alternative would therefore be protective of potential risks to human health and the environment.

Compliance with ARARs

This alternative would remediate subsurface soils to below calculated remediation levels. Surficial soils are below the TSCA PCB level for areas of unrestricted access (10 mg/kg).

Operation of the SVE system would conform to South Carolina air emission requirements (SCDHEC Air Pollution Control Regulation No. 62.5, Standard No. 8). Estimation of potential VOC emission rates is not as straightforward as for an air stripper, since the desorption rates from Site soils is unknown. For purposes of the FS, it is assumed that vapor phase carbon adsorption would be required to satisfy air quality standards. Emissions testing would be conducted during startup to establish actual requirements. The remedial health and safety plan would conform to 29 CFR 1910.120.

Potential location specific ARARs would be as described for Alternative SC-1 (Section 7.3.1).

Long-term Effectiveness and Permanence

Residual soil concentrations remaining after completion of this alternative would be at or below the VOC levels specified in Table 4.3. The SVE system would be operated until remediation levels for each compound were achieved. Those compounds that volatilize more readily would have substantially lower residual concentrations at the close of remediation since the duration of SVE operation would be dictated by removal of the less volatile VOCs.

Confirmation sampling could be required to verify that the remediation levels had been achieved before the SVE system could be shut down. Subsurface soils would no longer impact ground water above remediation levels following completion of this alternative. No long-term management of the Site would be required following implementation of this alternative.

A five year review of remedy would not be required since remediation levels would be achieved for all Site compounds. Conditions at the Site are anticipated to improve following implementation of this alternative.

Reduction of Toxicity, Mobility or Volume

This alternative would permanently reduce the volume of VOCs in soils by more than 95 percent (based on a reduction of TCE in TP-3 to 500 ug/kg). This level of reduction would be sufficient to keep Site soils from impacting ground water above remediation levels. VOCs are the only compounds that can impact ground water above MCLs. This alternative would therefore address the sole risk to ground water posed by Site soils.

Removal of the VOCs through SVE would satisfy SARA's preference for remedial actions involving treatment as a principal element. Extracted VOC levels that would exceed State ambient air requirements would be adsorbed onto activated carbon. The carbon would then either be incinerated or regenerated, depending on the volume of carbon available for reclamation.

Reductions in SVOCs cannot be accurately predicted at this time. Certain compounds are expected to be removed directly (e.g., 1,2,4-trichlorobenzene) while others have the potential to be removed through oxygen-stimulated biodegradation (e.g., phenol). Even if no reduction is achieved, SVOCs do not have the potential to impact ground water above remediation levels.

Short-term Effectiveness

This alternative presents no risks to the community or on-site workers during installation. Emissions during operation would be controlled to below allowable ambient levels. Because of the sparsely populated rural setting and setback from the road, it is unlikely that the community would notice operation of the SVE system.

Installation of the SVE system would require approximately one month and startup would require another month. The system would be operated until the soil remediation levels were achieved, a period of approximately 6 to 12 months based on experience at sites with similar geology and contaminants. Total implementation time for this alternative would be approximately 8 to 14 months.

Implementability

Target levels for SVE would be the calculated subsurface remediation levels presented in Table 4.3. The given levels can be achieved using standard SVE design and construction practices. Numerous monitoring wells have been installed at the Site and installation of the SVE extraction wells should present no difficulties. The SVE vacuum and control system is designed to run unattended. The only required utilities are electrical and telecommunication service, both of which can be brought to the Site from main service lines along County Road 72.

Control of air emissions would be coordinated with SCDHEC. Disposal of entrained water at an off-site facility, if required, should present no significant difficulties.

SVE is a demonstrated technology using standard process equipment that is offered by a number of vendors. Acquiring responsive and responsible bids to perform this work should not be difficult.

Cost

Construction costs for this alternative would include installation and materials for the SVE extraction wells and manifold piping. Operating costs would include leasing of the SVE equipment, disposal of spent carbon, and regular monitoring and maintenance. The detailed cost estimate for this alternative is presented in Appendix H.2. A summary of the estimated costs is given below:

Total Construction Costs -	$260,000
Present Worth O&M Costs -	$360,000
Total Present Worth Costs -	$620,000

8.0 SUMMARY OF ALTERNATIVES

The major findings of the Remedial Investigation with respect to potential remedial requirements are:

- Contaminants are present at the Site in soils in the immediate vicinity of the disposal area and in ground water in the saprolite and bedrock beneath the Site.
- Contaminants present in soils are related to distinct, localized, primarily shallow source areas of direct disposal (lagoons or drum disposal areas).
- Contaminants detected in soils consist of VOCs, SVOCs, pesticides and PCBs. PCBs were only detected at low levels in test pit source characterization samples and surface soil samples. PCBs were not found above TSCA remediation levels.
- Concentrations of inorganic constituents detected in soil samples collected from the Site are consistent with concentrations detected in soil samples from local background locations and with common ranges reported for natural soils. No elevated levels of inorganic constituents were observed in source characterization analyses.
- The only contaminants detected in ground water at the Site consist of VOCs. VOCs were detected in ground-water samples collected from saprolite and bedrock wells, with the highest concentrations occurring immediately beneath the source areas.
- Concentrations of inorganics detected in ground water are consistent with local background levels. Where MCLs were exceeded in downgradient monitoring wells, MCLs were also exceeded in the upgradient background wells, indicating naturally-occurring concentrations of inorganics above MCLs or contributions from particulate matter in the samples.

- The ground-water yield from wells installed in the upper portion of the bedrock are significantly higher than from wells installed in the saprolite or deeper bedrock. The dominant direction of ground water flow is to the southeast. Vertical gradients at the site are generally upward and of varying magnitude.

- Contaminants detected in ground water have not reached the closest perennial discharge area (Jones Creek, located to the southeast and east of the site). No contaminants were detected in analyses of surface water and stream sediments collected from Jones Creek. VOCs were not detected in monitoring wells installed immediately west of Jones Creek.

Ground water recovery, if required, would be best achieved through extraction wells screened in the saprolite/bedrock transition zone. Pumping in the transition zone would capture ground water from the saprolite above and the bedrock below. Capture zone efficiency would be evaluated through aquifer response measurements conducted during construction of the extraction system.

The volumes of materials removed during the immediate removal action and the generally low levels of chemical residuals found during the RI indicate that the great majority of waste materials disposed of at the Site have been removed. Unsaturated transport modeling determined that VOCs are the only contaminants in Site soils with the potential to impact ground water above remediation levels. The location and approximate extent of soils at the Site with concentrations of contaminants exceeding calculated soil remediation levels are the source areas RA-1, RA-2 and RA-3 identified in Figure 4.2.

8.1 GROUND WATER CONTROL

Site ground water currently poses no risks to human health or the environment. Potential risks to human health could occur in the future should a potable well be installed on the Medley Farm Site. The limited projected growth in the area, especially downgradient of the Site, and the extent of the existing municipal water supply indicate that construction of such a well is unlikely. Ground water migration in the future, even without treatment, would not pose a risk to the environment based on comparison with Federal Ambient Water Quality standards.

The following alternatives were subjected to detailed analysis for migration control:

- Alternative GWC-1A: No action
- Alternative GWC-1B: Long-term monitoring of ground water
- Alternative GWC-2A: Ground water extraction to MCLs across the Site, air stripping, discharge to Jones Creek
- Alternative GWC-3A: Ground water extraction to achieve MCLs at the property line, air stripping, discharge to Jones Creek.

The projected ground water extraction systems are presented in Figure 4.1. A summary of the evaluation of these alternatives under the detailed analysis criteria is presented below.

Overall Protection of Human Health and the Environment

The no action alternative would be protective of human health and the environment under current conditions. In the future, ground water migration will not pose a risk to the environment, but could pose a risk to human health if a potable well were to be installed at the Site. Currently there are no ground water receptors at the Site or immediately downgradient of the property, and future receptors are unlikely. Consequently, the risk estimate for the Site is an estimate of future hypothetical risk to human health.

The reasonable maximum carcinogenic risk for ingestion of ground water at the Site is estimated to be 1.1×10^{-2}. This future hypothetical risk level, without any remediation of Site ground water or soils, exceeds the EPA remediation goal of 10^{-4} to 10^{-6} risk levels.

Both ground water extraction alternatives (GWC-2A and GWC-3A) would be protective of human health and the environment, now and in the future, since both treatment alternatives would result in MCLs being achieved at all times at potential exposure points.

Compliance with ARARs

Concentrations of VOCs in ground water located beneath the Site exceed MCLs, consequently the no action alternatives (GWC-1A and GWC-1B) would not satisfy ARARs across the Site without a waiver. The no action alternatives would satisfy ground-water ARARs at the property line, which is a potential point of exposure, now and in the future. Both ground-water extraction alternatives (GWC-2A and GWC-3A) would satisfy ground-water ARARs. Construction of the ground-water extraction, treatment, and discharge systems for both Alternatives GWC-2A and GWC-3A would satisfy action-specific ARARs.

Long-term Effectiveness and Permanence

The magnitude of residual risks would remain unchanged under the no action alternatives (GWC-1A and GWC-1B). Since contaminants would remain at the Site, a review of remedy would be required every five years.

Alternatives GWC-2A and GWC-3A would permanently reduce the magnitude of potential risks at the Site through future exposure to ground water. Well point extraction of ground water and air stripping are demonstrated technologies that can be readily inspected and repaired, if necessary. Air stripping can readily achieve the concentrations necessary for discharge to Jones Creek. Periodic sampling of the treated effluent would be required.

Since ground water remaining at the Site after remediation would attain all protective standards, a review of remedy every five years would not be required at the completion of Alternatives GWC-2A or GWC-3A.

Reduction of Toxicity, Mobility or Volume

The no action alternative would not significantly reduce the toxicity, mobility or volume of contaminants in ground water. Alternative GWC-2A would permanently reduce the mass of VOCs in ground wa' by more than 99 percent. Alternative GWC-3A would permanently reduce the mass of VOCs in ground water by more than 95 percent.

Short-term Effectiveness

None of the alternatives would pose a risk to the community or remedial workers through implementation. Construction schedules for the alternatives would be:

- Alternative GWC-1A: None
- Alternative GWC-1B: 1 month
- Alternative GWC-2A: 3 months
- Alternative GWC-3A: 3 months.

Based on a batch-flushing model, implementation of Alternative GWC-2A would require approximately ten years and Alternative GWC-3A would require approximately six years.

Implementability

None of the alternatives would pose any significant difficulties regarding construction or operation. Design of any treatment system could not be completed until discharge re- :irements were defined.

Cost

Total present worth costs for the ground water control alternatives are presented in Table 8.1.

8.2 SOURCE CONTROL

Site soils pose no significant risks to human health or the environment under current conditions. Potential risks are only associated with ground water that has been impacted by the leaching of contaminants from certain areas of soils. Source control alternatives address those soils that could contribute contaminant levels to ground water above MCLs. Soil remediation levels based on leaching potential were derived in Appendix D. Site soils

TABLE 8.1

TOTAL PRESENT WORTH COSTS FOR RETAINED REMEDIAL ALTERNATIVES

MEDLEY FARM SITE

	Total Present Worth Costs
Groundwater Control	
GWC-1A	$140,000
GWC-1B	$790,000
GWC-2A (30 year duration)	$1,900,000
GWC-2A (10 year duration)	$1,200,000
GWC-3A (30 year duration)	$1,700,000
GWC-3A (6 year duration)	$900,000
Source Control	
SC-1	$140,000
SC-2	$1,000,000
SC-3	$620,000

exceeding these levels are depicted in Figure 4.2. VOCs are the only compounds found in soils that could cause ground water to exceed ARARs. The following alternatives were developed for Site soils that exceed calculated remediation levels and were subjected to detailed analysis:

- Alternative SC-1: No action
- Alternative SC-2: Cap soils above remediation levels
- Alternative SC-3: Soil vapor extraction (SVE) for soils above remediation levels

A summary of the evaluation of these alternatives under the detailed analysis criteria is presented below.

Overall Protection of Human Health and the Environment

Each of the source control alternatives would be protective of human health and the environment. Capping (Alternative SC-2) and SVE (Alternative SC-3) would reduce chemical loadings to ground water and thereby lessen any risks to potential downgradient receptors in the future.

Compliance with ARARs

The only identified ARAR for Site soils is the TSCA level of 10 mg/kg for PCBs in soils in areas of unrestricted access. The site-specific health-based level for PCBs in surficial soils based on human health considerations is 5.5 mg/kg. Concentrations at the Site, and therefore each of the source control alternatives, satisfy the TSCA requirement and the site-specific remediation level.

Three areas at the Site have the potential to cause VOCs in ground water to exceed MCLs. Capping and SVE would significantly reduce further leaching of contaminants to ground water from these areas. The cap in Alternative SC-2 would be designed to comply with RCRA performance standards. The SVE system in Alternative SC-3 would be operated in accordance with South Carolina air emission requirements.

Long-term Effectiveness and Permanence

VOCs are the only compounds found in Site soils with the potential to impact ground water above MCLs. The migration of VOCs to ground water would be permanently controlled by capping and SVE. A five year review of remedy would be required for the no action alternative and for capping because chemical residuals would be left at the Site. No review would be required following completion of SVE.

Reduction of Toxicity, Mobility or Volume

The no action alternative would not significantly reduce the toxicity, mobility or volume of remaining Site residuals. Capping would significantly reduce the mobility of Site residuals. SVE would significantly reduce the volume of Site residuals.

Short-term Effectiveness

None of the alternatives would pose a risk to the community or remedial workers through implementation. Construction schedules for the alternatives would be:

- Alternative SC-1: 0 months
- Alternative SC-2: 3 months
- Alternative SC-3: 2 months.

Duration of the no action alternative and capping would be indefinitely. Operation of the SVE system would require approximately 6 to 12 months.

Implementability

None of the alternatives would pose any significant construction or operational difficulties, although periodic inspections and repair of the cap would be required.

Cost

Total present worth costs for the source control alternatives are presented in Table 8.1.

APPENDIX C

ALTERNATE FUTURE RESIDENTIAL USE SCENARIO

MEDLEY FARM SITE

1.0 INTRODUCTION

Based upon the low population density and slow rate of growth in the area and development trends in Cherokee County, any pressure for a change in land use at the Medley Farm Site is not expected. It is anticipated that the Site and immediate environs will remain vacant for the foreseeable future; therefore, the following alternate future residential use scenario for the Site has been developed in order to estimate potential exposures and associated risk levels that would result from residential use of ground water from private wells that may be installed downgradient from the Site and off of the Medley property.

2.0 EXPOSURE ASSESSMENT

2.1 Characterization of Exposure Setting

In the alternate future residential use scenario, the population that potentially may be exposed to site-related chemicals are the hypothetical future residents living off-site, adjacent to the Medley property.

2.2 Identification of Exposure Pathways

The potential human exposure pathway for the Medley Farm Site identified in the context of the alternate future residential use scenario is exposure to site-related chemicals in ground water. Human exposure to ground water is of concern in this scenario with respect to its potential use by residents as drinking water. Potential exposure points are private wells that may be installed at the Medley property line downgradient from the Site.

2.3 Exposure Point Concentrations

Ground-water exposure point concentrations were derived by means of the CONMIG (Contaminant Migration) transport model (Walton, 1988). Data obtained from the saprolite and bedrock aquifer wells provided input to the model. Results are expressed as the 30-year average concentration of each chemical at the property line downgradient from the Site. Modeling assumptions and calculations used to estimate the future ground-water concentrations at the property line are presented in Appendix B. Ground-water exposure point concentrations for the chemicals of concern are shown in Table C.1.

2.4 Development of Chemical Intakes

Chemical-specific intakes were calculated for the ground water exposure pathway. The equation used to determine this exposure and the assumptions employed in the equation are presented below, along with a sample calculation for the pathway. A complete listing of the intakes calculated for the chemicals of concern is presented according to pathway in Table C.2.

Ground Water Ingestion

Exposure due to the drinking water pathway is calculated by:

$$\underset{\text{(mg/kg-day)}}{\text{Intake}} = \frac{Cw \times IR \times EF \times ED}{BW \times AT}$$

Where:

Cw	=	Chemical concentration in water (mg/liter)
IR	=	Ingestion rate (liters/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW		Body weight (kg)
AT	=	Averaging time (days)

Variable values:

Cw	=	Representative groundwater concentrations
IR	=	2 liters/day (U.S. EPA, 1990)
EF	=	365 days/year (U.S. EPA, 1989)
ED	=	30 years (U.S. EPA, 1990)
BW	=	70 kg (U.S. EPA, 1989)
AT	=	25,550 days for carcinogenic effects (70 years x 365 days/year); 10,950 days for noncarcinogenic effects (30 years ED x 365 days/year) (U.S. EPA, 1989).

A sample calculation for intake through ingestion of ground water is presented below for methylene chloride (for carcinogenic effects):

$$\text{Intake from drinking water ingestion} = \frac{(3.0E\text{-}4\ mg/l)\ (2l/day)\ (365\ days/year)\ (30\ years)}{(70\ kg)\ (25{,}550\ days)}$$

$$= 3.7E\text{-}6\ mg/kg/day$$

3.0 RISK CHARACTERIZATION

Potential human health risks due to reasonable maximum exposure have been estimated for each chemical of concern. Carcinogenic and non-carcinogenic effects were calculated separately. Non-carcinogenic effects of carcinogenic compounds were included in the calculation of the non-carcinogenic hazard index when appropriate reference doses were available.

3.1 Carcinogenic Risks

Chemical-specific risks for the compounds are presented in Table C.3 for the ground water pathway. The total carcinogenic risk for the pathway was calculated by summing the carcinogenic risks posed by each of the carcinogens (Total Pathway Risk, Table C.3). This method of adding risks, recommended by EPA in its Guidelines for the Health Risk

Assessment of Chemical Mixtures (U.S. EPA, 1986), may be overly conservative in that the slope factors, as an upper 95th percentile estimate of potency, are not strictly additive

The reasonable maximum carcinogenic risk for ingestion of ground water is estimated to be 5.5×10^{-5} for the alternate future residential use scenario.

3.2 Non-carcinogenic Effects

The risk characterization for non-carcinogenic effects is summarized in Table C.4. To assess the overall potential for non-carcinogenic effects posed by exposure to multiple chemicals, a hazard index equal to the sum of the hazard quotients was calculated (in accordance with U.S. EPA, 1986) for the pathway. As with the hazard quotient, if the hazard index exceeds unity there may be concern for potential adverse health effects. The hazard index for ground water ingestion under the alternate future residential use scenario is 2.9×10^{-2}.

3.3 Discussion of Uncertainty

The estimates of human health risks developed in this risk assessment required a considerable number of assumptions about exposure and subsequent adverse human health effects. Most of the site-specific uncertainties are included in the exposure assessment (Section 2.0). Exposure point concentrations for site-related chemicals in ground water were estimated from measured chemical concentration in monitoring wells by means of a ground-water transport model. Key model assumptions are listed in Appendix B. The possibility that a drinking water well would be constructed at the property line, where exposure point concentrations were estimated, is unlikely considering the availability of public water in the Medley Farm area.

Uncertainty associated with the toxicity values is summarized in Tables 3.9 and 3.10 of the FS Report. Only one chemical of potential concern in ground water, benzene, is a Class A (known) carcinogen. Benzene was found at low concentrations and was responsible for a minor portion (7.1×10^{-9}) of the risk due to ground-water ingestion. The chemical that contributed most to the estimate of cancer risk through the ground-water ingestion pathway was 1,1-dichloroethene. This chemical, however, with a weight-of-evidence classification of C, has not shown evidence of carcinogenicity in humans and only limited evidence in animals.

3.4 Summary of Human Health Risk

Estimated carcinogenic risk due to exposure to site-related chemicals in ground water via ingestion is 5.5×10^{-5}. This is a potential future risk based on the scenario of the ground-water plume reaching the property boundary and a residential drinking water well being installed there. There are presently no exposure points (wells) on the Site or downgradient at the property line. There are no existing receptors near the Medley property downgradient from the Site and public water supply is presently available in the area. The estimated risk level is within the EPA remediation goal of 10^{-4} to 10^{-6}.

No significant risk due to non-carcinogenic effects of site-related chemicals has been identified under the alternate future residential land use conditions. Total non-carcinogenic hazard is estimated to be 2.9×10^{-2}, which is below unity, the EPA hazard quotient level that would indicate a potential for adverse effect.

REFERENCES

U.S. Environmental Protection Agency. 1990. Exposure Factors Handbook. Office of Health and Environmental Assessment, USEPA, Washington, D.C.

U.S. Environmental Protection Agency. 1989. Risk Assessment Guidance for Superfund. Volume 1. Human Health Evaluation Manual (Part A). Interim Final. Office of Emergency and Remedial Response. USEPA, Washington, D.C.

U.S. Environmental Protection Agency. 1988. Superfund Exposure Assessment Manual. Office of Remedial Response, USEPA, Washington, D.C.

U.S. Environmental Protection Agency. 1986. Guidelines for the Health Risk Assessment of Chemical Mixtures. Federal Register 51:34028.

TABLE C.1

EXPOSURE CONCENTRATIONS - GROUND WATER
MEDLEY FARM SITE

Chemical	Concentration (μg/liter)
1,1-Dichloroethene	7.2
1,1-Dichloroethane	0.34
1,1,1-Trichloroethane	11.7
1,1,2-Trichloroethane	0.04
1,2-Dichloroethane	0.9
1,2-Dichloroethene (total)	0.1
Acetone	0.04
Benzene	0.02
2-Butanone	0.03
Chloroform	0.03
Chloromethane	0.05
Methylene Chloride	0.3
Tetrachloroethene	0.6
Trichloroethene	2.6

Concentrations are projected 30-year average concentrations at the property line

TABLE C.2
ESTIMATED EXPOSURES BY PATHWAY
MEDLEY FARM SITE

Chemical	Reasonable Maximum Daily Dose (mg/kg/day) From Groundwater Ingestion For Carcinogenic Effects	For Noncarcinogenic Effects
1,1 Dichloroethene	8.8E-05	2.1E-04
1,1 Dichloroethane		9.7E-06
1,1,1 Trichloroethane		3.3E-04
1,1,2 Trichloroethane	4.9E-07	1.1E-06
1,1,2,2-Tetrachloroethane		
1,2-Dichloroethane	1.1E-05	
1,2-Dichloroethene (total)		2.9E-06
1,2-Dichloropropane		
Acetone		1.1E-06
Benzene	2.4E-07	
2-Butanone		8.6E-07
Chloroform	3.7E-07	8.6E-07
Chloromethane	6.1E-07	
Ethylbenzene		
Methylene Chloride	3.7E-06	8.6E-06
Styrene		
Tetrachloroethene	7.3E-06	1.7E-05
Trichloroethene	3.2E-05	
Vinyl Chloride		
1,2,4-Trichlorobenzene		
Butylbenzylphthalate		
Di-n-butylphthalate		
Di-n-octylphthalate		
bis(2-Ethylhexyl)phthalate		
Toxaphene		
PCB		

TABLE C.3
RISK CHARACTERIZATION: CARCINOGENIC EFFECTS
MEDLEY FARM SITE

Chemical	CDI (mg/kg/day)	Slope Factor (mg/kg/day)-1	Chemical-specific Risk
Exposure Pathway: Ingestion of Ground Water			
1,1-Dichloroethene	8.8E-5	6.0E-1	5.3E-5
1,1,2-Trichloroethane	4.9E-7	5.7E-2	2.8E-8
1,2-Dichloroethane	1.1E-5	9.1E-2	1.0E-6
Benzene	2.4E-7	2.9E-2	7.1E-9
Chloroform	3.7E-7	6.1E-3	2.2E-9
Chloromethane	6.1E-7	1.3E-2	8.0E-9
Methylene Chloride	3.7E-6	7.5E-3	2.8E-8
Tetrachloroethene	7.3E-6	5.1E-2	3.7E-7
Trichloroethene	3.2E-5	1.1E-2	3.5E-7
		Total Pathway Risk	5.5E-5

TABLE C.4
RISK CHARACTERIZATION: NONCARCINOGENIC EFFECTS
MEDLEY FARM SITE

Chemical	CDI (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient
Exposure Pathway: Ingestion of Ground Water			
1,1-Dichloroethene	2.1E-4	9E-3	2.3E-2
1,1-Dichloroethane	9.7E-6	1E-1	9.7E-5
1,1,1-Trichloroethane	3.3E-4	9E-2	3.7E-3
1,1,2-Trichloroethane	1.1E-6	4E-3	2.9E-4
1,2-Dichloroethene (total)	2.9E-6	2E-2	1.4E-4
Acetone	1.1E-6	1E-1	1.1E-5
2-Butanone	8.6E-7	5E-2	1.7E-5
Chloroform	8.6E-7	1E-2	8.6E-5
Methylene Chloride	8.6E-6	6E-2	1.4E-4
Tetrachloroethene	1.7E-5	1E-2	1.7E-3
		Pathway Hazard Index	2.9E-2

APPENDIX E

PROTECTIVE LEVELS FOR SITE CHEMICALS

GROUND WATER

Six chemicals present in the ground water at the Medley Farm Site lack established water quality criteria for consideration in development of remediation alternatives. Target concentrations are required for application at the point of exposure identified in the baseline risk assessment, i.e., ground-water ingestion. It therefore was necessary to develop health-based ground-water levels for these chemicals. The preliminary pollutant limit value (PPLV) concept was used to obtain risk-based levels protective of human health.

The preliminary pollutant limit value concept has been used extensively, primarily by the U.S. Army to help establish cleanup levels for soil and water, and goals for preventing undue exposure to toxic chemicals from uncontrolled hazardous waste sites. The methods involved are described in numerous agency reports and in at least one peer-reviewed journal (Rosenblatt et al., 1986). The application of this concept to the Medley Farm Site is presented below.

Development of Preliminary Pollutant Limit Values

Preliminary pollutant limit values (PPLVs) were calculated using the following standard parameter values for chronic human exposure via the ground-water ingestion pathway: 70 kg adult body weight and an adult drinking water consumption rate of 2 liters per day (U.S. EPA, 1990a). Site-specific parameter values used here (exposure frequency, exposure duration, and averaging time) are taken from the Risk Assessment for the Site (Section 3.3.1 of this Feasibility Study). Estimates of acceptable daily dose (D_T) were derived from the best available toxicological data, as explained below for each chemical.

The PPLV for ingestion of ground water is calculated by:

$$\text{Ground Water PPLV} = \frac{D_T \times \text{body weight} \times \text{averaging time}}{\text{daily water intake} \times \text{exposure frequency} \times \text{exposure duration}}$$

Derivation of the respective PPLVs are presented below for each chemical and summarized in Table E.1.

1,1-Dichloroethane

Although 1,1-dichloroethane has been classified as Group C (possible human carcinogen) by the EPA Carcinogen Assessment Group, the slope factor has been withdrawn pending review (U.S. EPA, 1990c). The oral reference dose for noncarcinogenic effects (RfD) of 0.1 mg/kg/day (U.S. EPA, 1990b) is therefore used as the acceptable D_T for 1,1-dichloroethane.

The health-based ground-water level, or PPLV, for 1,1-dichloroethane is calculated by:

$$\text{Ground Water PPLV} = \frac{0.1 \text{ mg/kg/day} \times 70 \text{ kg} \times 10950 \text{ days}}{2 \text{ liters} \times 365 \text{ days/yr} \times 30 \text{ years}}$$

$$= 3.5 \text{ mg/l}$$

Due to the fact that 1,1-dichloroethane is a Class C carcinogen and the ground water PPLV was calculated using the RfD, which is the toxicity factor for noncarcinogenic effects, a safety factor of 10 is applied to the PPLV. Thus, adjusted ground water PPLV = 0.35 mg/l.

Acenaphthalene

The only human health standard available for use as a D_T for acenaphthalene is the oral RfD of 0.06 mg/kg/day, verified by the EPA RfD Work Group (U.S. EPA, 1990b).

The health-based ground-water level for acenaphthalene is therefore calculated as follows:

$$\text{Ground Water PPLV} = \frac{0.06 \text{ mg/kg/day} \times 70 \text{ kg} \times 10950 \text{ days}}{2 \text{ liters} \times 365 \text{ days/yr} \times 30 \text{ years}}$$

$$= 2.1 \text{ mg/l}$$

Acetone

The EPA Carcinogen Assessment Group has classified acetone as a group D substance, i.e., not classifiable as to human carcinogenicity. The oral RfD of 0.1 mg/kg/day (U.S. EPA, 1990c) is therefore used a the acceptable daily dose for acetone.

The health-based ground-water level for acetone is calculated as follows:

$$\text{Ground Water PPLV} = \frac{0.1 \text{ mg/kg/day} \times 70 \text{ kg} \times 10950 \text{ days}}{2 \text{ liters} \times 365 \text{ days/yr} \times 30 \text{ years}}$$

$$= 3.5 \text{ mg/l}$$

Benzoic Acid

Benzoic acid has been classified as a group D substance by the EPA Carcinogen Assessment Group. Therefore, the oral RfD of 4 mg/kg/day (U.S. EPa, 1990c) is used as the acceptable daily dose for benzoic acid.

The health-based ground-water level for benzoic acid is calculated as follows:

$$\text{Ground Water PPLV} = \frac{4 \text{ mg/kg/day} \times 70 \text{ kg} \times 10950 \text{ days}}{2 \text{ liters} \times 365 \text{ days/yr} \times 30 \text{ years}}$$

$$= 140 \text{ mg/l}$$

Chloromethane

Chloromethane has been classified as Group C (possible human carcinogen) by the Human Health Assessment Group of the EPA. An acceptable daily dose for chloromethane has been derived based on a cancer risk of 10^{-5} and a cancer slope factor of 1.3×10^{-2} $(\text{mg/kg/day})^{-1}$ for the oral route.

Thus,

$$D_T = \frac{1 \times 10^{-5}}{1.3 \times 10^{-2}}$$

$$= 7.7 \times 10^{-4} \text{ mg/kg/day}$$

The health-based ground-water level for chloroemethane is calculated as follows:

$$\text{Ground Water PPLV} = \frac{7.7E\text{-}4 \times 70 \text{ kg} \times 25{,}550 \text{ days}}{2 \text{ liters} \times 365 \text{ days/yr} \times 30 \text{ years}}$$

$$= 0.063 \text{ mg/l}$$

Diethylphthalate

Diethylphthalate, like acetone and benzoic acid, has been classified group D, not classifiable as to human carcinogenicity. The acceptable daily dose is therefore taken to be the oral RfD, which is 0.8 mg/kg/day (U.S. EPA, 1990c).

The health-based ground-water level for diethylphthalate is calculated by:

$$\text{Ground Water PPLV} = \frac{0.8 \text{ mg/kg/day} \times 70 \text{ kg} \times 10950 \text{ days}}{2 \text{ liters} \times 365 \text{ days/yr} \times 30 \text{ years}}$$

$$= 28 \text{ mg/l}$$

Phenol

Phenol is also classified group D and the oral RfD of 0.6 mg/kg/day (U.S. EPA, 1990c) is used as an acceptable daily dose.

Therefore:

$$\text{Ground Water PPLV} = \frac{0.6 \text{ mg/kg/day} \times 70 \text{ kg} \times 10950 \text{ days}}{2 \text{ liters} \times 365 \text{ days/yr} \times 30 \text{ years}}$$

$$= 21 \text{ mg/l}$$

SOIL

The preliminary pollutant limit value concept was also used to develop a health-based level for PCBs in soil at the Medley Farm Site. PPLVs were calculated using the standard and site-specific parameter values for human exposure that were used for the Risk Assessment in Section 3.3.1 of this Feasibility Study. Potentially significant routes of entry for PCBs in surface soil are ingestion and dermal absorption. A single pathway preliminary pollutant limit value (SPPPLV) is calculated for both of these routes of entry. The soil PPLV is then calculated as $\dfrac{1}{\Sigma \dfrac{1}{\text{SPPPLV}}}$, after Rosenblatt et al. (1982).

An acceptable daily dose for PCBs has been derived based on a cancer risk of 10^{-6} and a cancer slope factor of 7.7/mg/kg/day (U.S. EPA, 1990c). Thus,

$$D_T = \frac{1}{7.7} \times 10^{-6}$$

$$= 1.3 \times 10^{-7} \text{ mg/kg/day}$$

The SPPPLV for soil ingestion is calculated as follows:

$$\text{SPPPLV for Ingestion} = \frac{D_T \times BW_c \times AT}{IR_c \times FI \times ER_c \times ED_c \times CF} + \frac{D_T \times BW_a \times AT}{IR_a \times FI \times ER_a \times ED_a \times CF}$$

$$= \frac{1.3\text{E-7mg/kg/d} \times 16 \text{ kg} \times 25550\text{d}}{0.2 \text{ g/d} \times .17 \times 24 \text{ d/yr} \times 6 \text{ yr} \times 10^{-3} \text{ kg/g}} + \frac{1.3\text{E-7 mg/kg/d} \times 70 \text{ kg} \times 25550\text{d}}{0.1 \text{ g/d} \times .17 \times 24 \text{ d/yr} \times 15 \text{ yr} \times 10^{-3} \text{ kg/g}}$$

$$= 1.085\text{E+1} + 2.374\text{E+1}$$

$= \quad 34.6$ mg/kg

The SPPPLV for dermal absorption of soil is calculated as follows:

$$\text{SPPPLV for Dermal Absorption} = \frac{D_T \times BW_c \times AT}{SA_c \times AF \times ABS_c \times EF_c \times ED_c \times CF} + \frac{D_T \times BW_a \times AT}{SA_a \times AF \times ABS_a \times EF_a \times ED_a \times CF}$$

$$= \frac{1.3\text{ E-7 mg/kg} \times 37\text{ kg} \times 25550\text{d}}{4046\text{ cm}^2\text{/event} \times 2.11\text{ mg/cm}^2 \times 0.036 \times 24\text{ d/yr} \times 15\text{ yr} \times 10^{-6}\text{ kg/mg}}$$

$$+ \frac{1.3\text{ E-7 mg/kg} \times 70\text{ kg} \times 25550\text{d}}{3160\text{ cm}^2\text{/event} \times 2.11\text{ mg/cm}^2 \times 0.018 \times 24\text{ d/yr} \times 15\text{ yr} \times 10^{-6}\text{ kg/mg}}$$

$= \quad 1.111E+0 + 5.381E+0$

$= \quad 6.5$ mg/kg

The soil PPLV for the ingestion and dermal absorption paths are therefore:

$$\text{Soil PPLV} = \frac{1}{\frac{1}{34.6} + \frac{1}{6.5}}$$

$= \quad 5.5$ mg/kg

TABLE E.1

HEALTH BASED LEVELS

Compound	PPLV
Ground Water	(mg/l)
1,1-Dichloroethane	0.35
Acenaphthalene	2.1
Acetone	3.5
Benzoic Acid	140.0
Chloromethane	0.063
Diethylphthalate	28.0
Phenol	21.0
Soil	(mg/kg)
PCBs	5.2

4 9 0 2 0 3

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